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NATIONAL DAM SAFETY PROGRAM. FOFFEL LAKE DAM (MO 20494), MISSOU--ETC(U)
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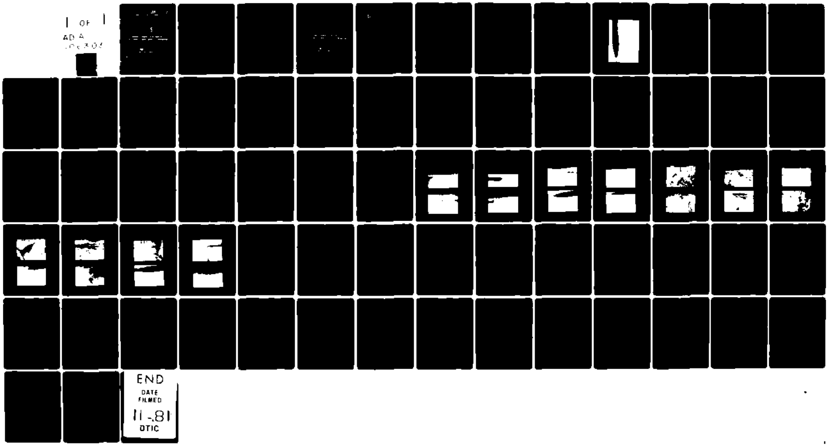

LEVEL

MISSOURI-KANSAS CITY BASIN

AD A106303

POPPEL LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 29494

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
St. Louis District

DTIC FILE COPY

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

DECEMBER 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED Final Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Black & Veatch, Consulting Engineers	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE ...ember 1980
	13. NUMBER OF PAGES Approximately ...
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) National Dam Safety Program. ... Lake Dam (MO ...), Missouri-Arkansas ... Basin, ... County, Missouri. Phase I Inspection Report.	15. SECURITY CLASS. (of this report) UNCLASSIFIED
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16. DISTRIBUTION STATEMENT (of this Report)	
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18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

FOFFEL LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 20494

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

DECEMBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Foffel Lake Dam, MO. I.D. No. 20494 Phase I Inspection Report.

This report presents the results of field inspection and evaluation of the Foffel Lake Dam (MO 20494).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — Date: 22 ~~26~~ MAY 1981

APPROVED BY: SIGNED — Colonel, CE, District Engineer — Date: 26 MAY 1981

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Justification

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FOFFEL LAKE DAM

JOHNSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20494

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

DECEMBER 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Foffel Lake Dam
State Located	Missouri
County Located	Johnson County
Stream	Tributary of Clear Fork of Blackwater River
Date of Inspection	11 December 1980

Foffel Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure of the dam would threaten lives and property. The estimated damage zone extends approximately one and one-half miles downstream of the dam. Within the estimated damage zone are two trailer courts with more than fifteen trailer units, a railroad, a motel and service station, commercial development, more than five residential dwellings, and two highways. Contents of the estimated downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 25 percent of the probable maximum flood. The spillway will pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the downstream damage zone and the volume of water stored in the reservoir, the spillway design flood should be 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in good condition. Deficiencies visually observed by the inspection team were extremely steep upstream slope, erosion and sloughing of the upstream slope at the waterline due to wave action, erosion of the unlined spillway discharge channel at the embankment toe, seepage on the downstream slope near the toe of the north-south portion of the embankment and animal burrows in the embankment. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Edwin R Burton

Edwin R. Burton, PE
Missouri E-10137

Harry L Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
FOFFEL LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Foffel Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary of the Clear Fork of the Blackwater River (see Plate 1). The lake appears to have been formed by the damming of a highway construction borrow pit. The watershed is an area of minor topographic relief of low hills consisting of about 25 percent grasslands, 50 percent croplands, and 25 percent lake surface area. The dam is approximately 1,635 feet long along the crest and 20 feet high. The dam crest is about 8 feet wide. The downstream face of the dam has a nonuniform slope.

(2) The spillway is an 18-inch, 40 feet long corrugated metal pipe conduit located near the right end of the embankment. Left and right are used herein for directional reference while looking downstream. The flow through the conduit is not controlled. There is no trash rack or headwall. The spillway outlet channel consists of a narrow, unlined section and a relatively flat overflow section.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in east-central Johnson County, Missouri, as indicated on Plate 1. The lake formed by the dam is located in the area shown on the United States Geological Survey 7.5 minute series quadrangle map for Knob Noster, Missouri in Section 15 of T46N, R24W.

[illegible] dams [illegible] impoundment [illegible] base [illegible] impoundment [illegible] small [illegible] height less than [illegible] feet [illegible] feet [illegible] equal to [illegible] feet.

Hazard Classification. The hazard [illegible] Corps of Engineers [illegible] this dam [illegible] operating [illegible] the dam [illegible] damage [illegible] highways [illegible] estimated [illegible] damage [illegible] downstream of the dam [illegible] damage [illegible] more than fifteen [illegible] development [illegible] and two highways [illegible] contents of the estimated downstream damage [illegible] verified by the inspection team.

e. Ownership. The dam is owned by [illegible] Knob Noster, Missouri [illegible].

f. Purpose of Dam. The dam forms a [illegible] lake.

g. Design and Construction History. [illegible] and construction were not available.

h. Normal Operating Procedure. Normal [illegible] evaporation [illegible] maintain [illegible] water [illegible].

PERTINENT DATA

a. Drainage area [illegible]

b. Discharge at damsite [illegible]

Normal discharge at the dam [illegible] gated metal pipe conduit.

Estimated experienced maximum flood at damsite [illegible] unknown.

Estimated ungated spillway capacity at maximum pool [illegible] Probable Maximum Flood [illegible].

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - 18-inch corrugated metal pipe.

(2) Invert elevation - 832.0 feet m.s.l.

(3) Gates - None.

(4) Upstream channel - None.

(5) Downstream channel - Discharges to an eroded ditch located near the toe of the dam and then to a 30-inch concrete culvert through the embankment of Highway 50.

j. Emergency Spillway - None.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

Operational records and documentation of past floods were unavailable.

2.4 GEOLOGY

The site for the dam and reservoir is located across a broad shallow swale on a gently sloping hillside. The dam impounds the drainage of a small intermittent headwater tributary of the Clear Fork of the Blackwater River.

The soils in the area of the dam and reservoir are the Deepwater, Haig and Sampsel soil series. The Deepwater soil series consists of deep, moderately well-drained soils formed in residuum from shales on uplands. The Deepwater soils are classified for engineering purposes as ML or CL materials. The Haig soil series consists of poorly drained soils formed in loess under prairie vegetation on uplands. The Haig soils are classified for engineering purposes as CL, OL, and CH materials. The Sampsel soil series consists of poorly drained soils on ridgetops (Reference 1).

The bedrock in the area of the dam and reservoir consists of interbedded shale, siltstone, and sandstone of the Cabiness subgroup, Cherokee group of the Des Moinesian series of the Pennsylvanian system. The depth to bedrock is not known (Reference 2).

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available. Thus, an assessment of the design, construction, and operation could not be made. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c *Validity*. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Foffel Lake Dam was made on 11 December 1980. The inspection team consisted of Edwin Burton, team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; Alan Reif, civil engineer; and Paul MacRoberts, hydraulics/hydrologic engineer. The dam appeared to be in good condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracking, sliding, or other signs of settlement or instability were observed. However, the upstream slope of the embankment is steep and some minor sloughing on the upstream face has occurred as a result of undercutting by wave action. No instruments to measure the performance of the dam were observed.

A seepage area was observed on the downstream slope of the embankment near the toe. Wet soils and standing water have provided an area for cattail growth. Clear flow of less than 1 gpm was observed at the lower end of the seepage area. No toe drains or relief wells were observed.

The dam crest has a mowed grass/weed cover with some worn spots, probably due to foot and vehicle traffic. Wave action erosion was observed on the upstream slope. There is no riprap protection on this dam. The ditch leading from the 18-inch corrugated metal pipe conduit spillway is cutting into the toe of the embankment.

Two or three small trees, 1-inch diameter or less, are growing on the embankment. A few small animal burrows were observed on both the upstream and downstream faces.

No evidence was found to indicate that the embankment had ever been overtopped.

There was evidence that a maintenance program was in effect which includes mowing of the crest grass/weeds and the cutting of small trees on the embankment.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The spillway is an 18-inch corrugated metal pipe conduit located near the right end of the embankment with no control mechanism. There was evidence of erosion in the unlined spillway discharge channel downstream of the spillway. The spillway was considered to be in good condition. It

should be noted that an abnormally large spillway discharge would probably cause damage to the embankment in the vicinity of the spillway.

There was no development in the spillway area which would suffer damage due to flow through the spillway.

d. Geology. The soil in the area around the dam and reservoir consists of silty clay. The soils were visually classified as CL materials.

No rock outcrops were observed. It is anticipated the foundation and abutments consist of either shale or silty clay. The depth to bedrock could not be determined.

Auger samples of the materials in the embankment were taken with an Oakfield sampler near the downstream crest of the embankment. The materials in the sample were visually classified for engineering purposes as ML and CL materials. Based on these samples, it is surmised that the embankment is constructed of materials similar to those in the samples.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. The watershed for the lake is primarily cultivated agricultural land. The contributing watershed was not particularly channelized. Some small ditches were observed. The contributing area was essentially clear of debris and trees. Some brush was observed along the east watershed boundary. The lake was noted to be clean with no siltation.

f. Downstream Channel. The spillway discharges to a channel which enters a 30-inch concrete culvert under U.S. Highway 50. The natural channel downstream from Highway 50 is relatively clear, although the overbanks have extensive brush and tree growth. Large flows passing the dam would probably overflow the highway at its low point which is approximately 1,000 feet west of the dam.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control.

The potential for sloughing, erosion, or sliding of embankment material is enhanced by the presence of the relatively steep side slopes and the lack of erosion protection on the upstream face.

The growth of trees and brush, if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and leave voids through which water can pass.

The area of seepage on the downstream slope which was observed should be monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment and/or abutments.

The eroded unlined discharge channel at the embankment toe near the right abutment should be repaired and protected against further erosion.

The absence of riprap on the upstream slope of the dam has resulted in wave action erosion. If not corrected wave action will continue to erode the embankment and could lead to slope stability problems.

Burrowing animals will continue to damage the embankment if a program is not undertaken to eliminate them. Piping failure of embankments have resulted from damage caused by burrowing animals.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, seepage, evaporation, transpiration, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

There was evidence that maintenance has been performed which includes the mowing of the crest grass/weeds and the cutting of small trees and brush.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

A maintenance program should continue to include mowing the grass cover and cutting small trees and brush on the embankment in order to discourage animal burrowing.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from the USGS Knob Noster Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The spillway appears to be in good condition. The lake level at the time of the inspection (El. 831.6) was below the spillway invert level. There were no obstructions to flow in the immediate downstream channel. The spillway discharge enters a 30-inch concrete highway culvert immediately downstream from the dam's toe near the center of the dam.

(2) There is no emergency spillway for this dam.

(3) Spillway discharges may endanger the integrity of the dam in the immediate vicinity of the spillway.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 25 percent of the probable maximum flood without overtopping the dam. The spillway will pass the one percent chance flood estimated to have a peak outflow of 5 cfs developed by a 24-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the downstream hazard and the volume of water stored in the reservoir, the appropriate spillway design flood should be 100 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 77 cfs of the total discharge from the reservoir of 85 cfs. The estimated duration of overtopping is 8.5 hours with a maximum height of 0.8 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 820 cfs of the total discharge from the reservoir of 830 cfs. The estimated duration of overtopping is 10.7 hours with a maximum height of 1.6 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately one and one-half

miles downstream of the dam. Within the defined damage zone are two trailer courts with more than fifteen trailer units, a motel and service station, a railroad, commercial development, more than five residential dwellings, and two highways. These various facilities could be severely damaged and lives lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team. There does not appear to be any flood plain regulations or other constraints in force to limit future downstream development.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. It is not known whether or not any changes have been made to the dam subsequent to its construction.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning, and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion on the upstream slope, erosion of the unlined spillway discharge channel at the embankment toe near the right abutment, the seepage area on the downstream slope, and animal burrows in the embankment. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The spillway size and/or height of the dam would need to be increased or the lake level would need to be permanently lowered to increase available flood storage to effectively pass the recommended spillway design flood.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) Riprap should be placed on the upstream face of the dam to an elevation above normal lake level to prevent wave induced erosion of the embankment material.

(2) The seepage area noted during the visual inspection should be closely monitored and documented as to quantity and quality of flow. Any significant changes should be evaluated.

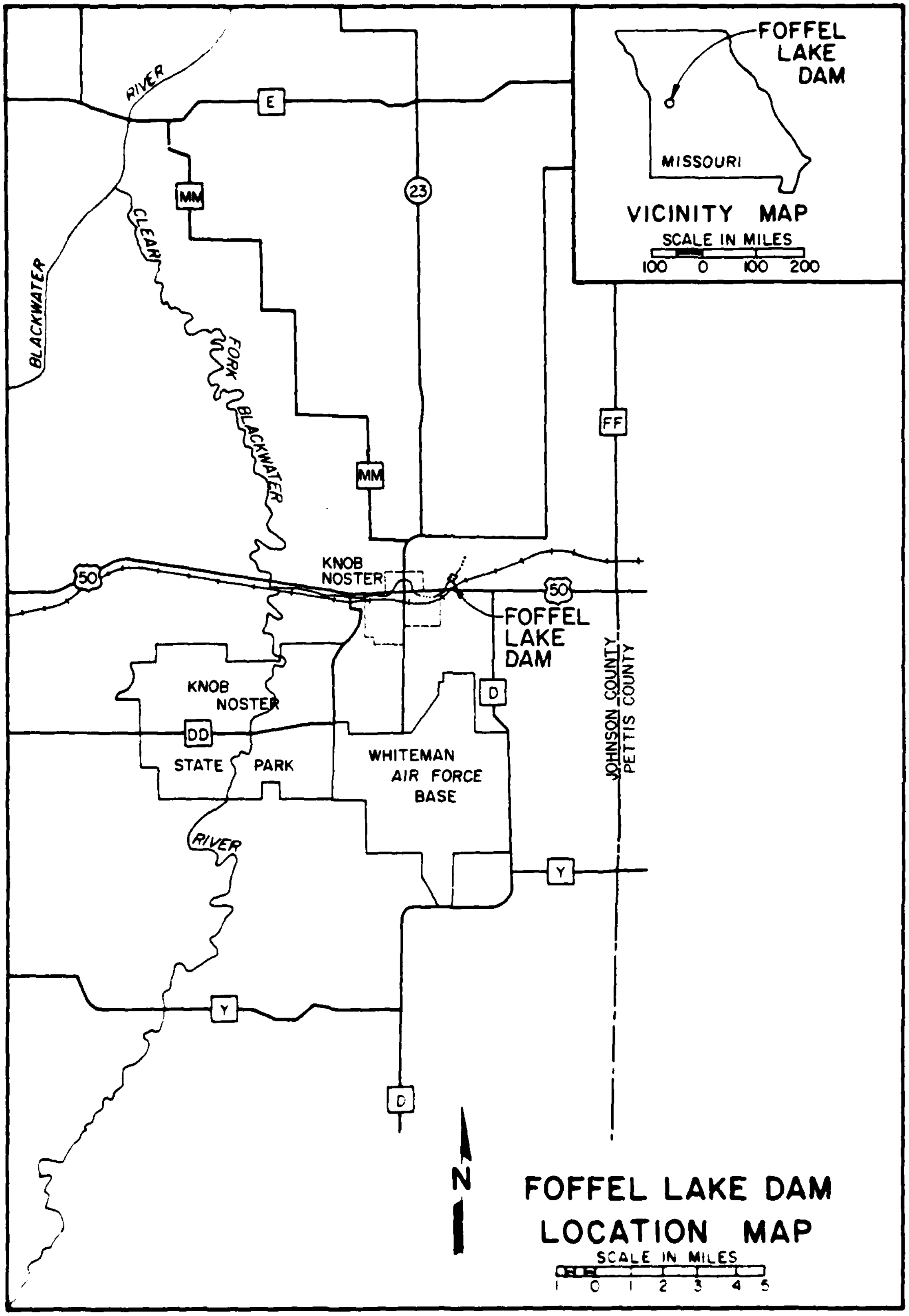
(3) A maintenance program to remove and control the growth of brush and trees on the embankment should be continued. Grass/weed cover on the embankment should be cut periodically.

(4) The spillway discharge ditch on the downstream slope of the embankment near the right abutment should be repaired. A paved ditch or other means of protection may be required to control the concentrated runoff.

(5) The animal burrows in the embankment should be corrected since they contribute to the occurence of piping. Control measures should be implemented under the direction of a qualified engineer to discourage animal activity in the area. The embankment slope should be monitored during this repair.

(6) Seepage and stability analyses should be performed.

(7) A detailed inspection of the dam should be made periodically. This inspection should include measurement of seepage flows and analyzing water samples taken from the seep and lake. The findings of these inspections should be documented and made a matter of record. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.



FOFFEL
LAKE
DAM
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
RIVER
E
MM
23
CLEAR
BLACKWATER
FORK
BLACKWATER
FF
MM
KNOB
NOSTER
50
50
FOFFEL
LAKE
DAM
KNOB
NOSTER
D
JOHNSON COUNTY
PETTIS COUNTY
DD
STATE PARK
WHITEMAN
AIR FORCE
BASE
RIVER
Y
Y
D
N
FOFFEL LAKE DAM
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5

PLATE I

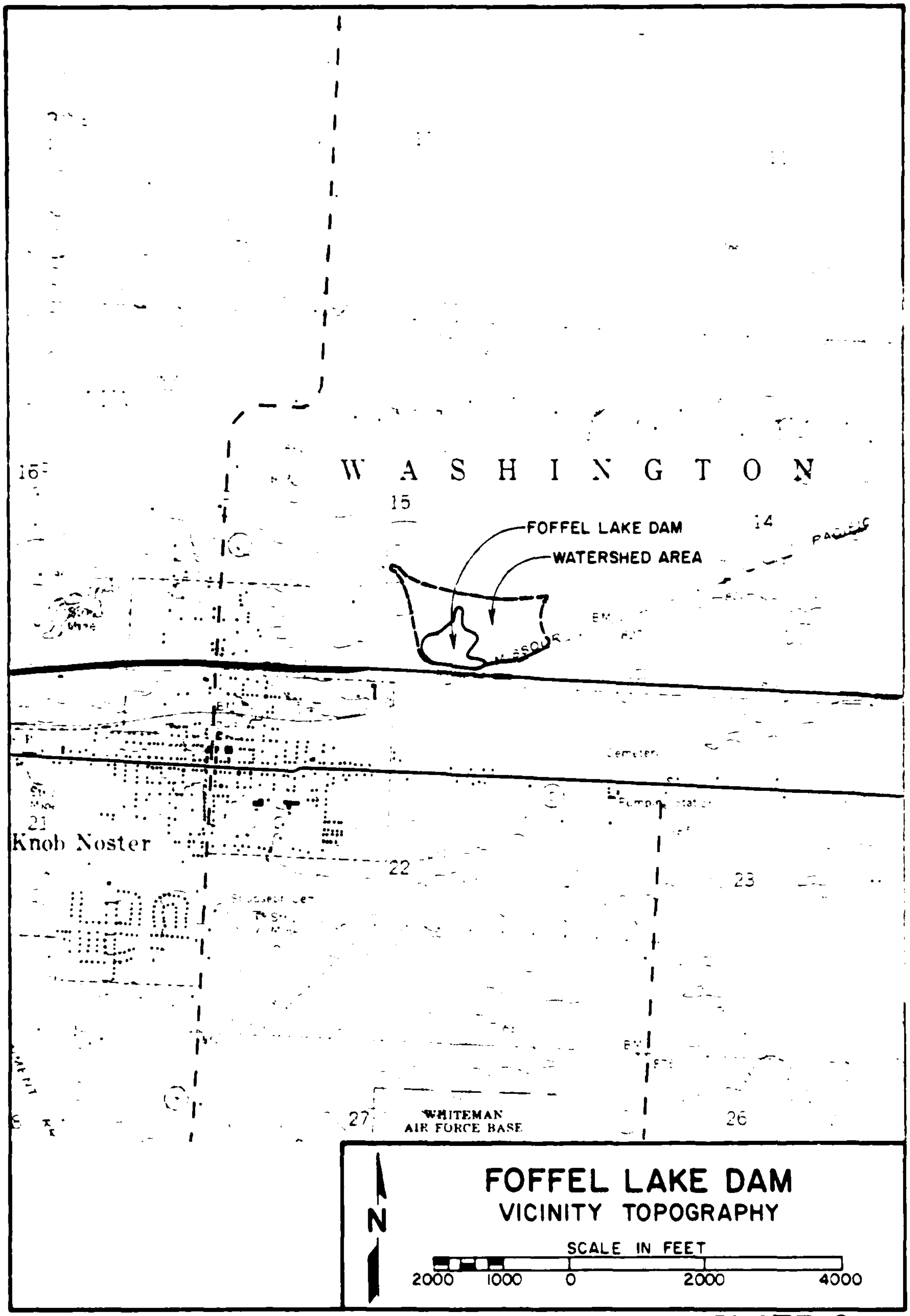

WASHINGTON
15
14
16
21
22
23
27
26
FOFFEL LAKE DAM
WATERSHED AREA
Knob Noster
WHITEMAN
AIR FORCE BASE
N
FOFFEL LAKE DAM
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

PLATE 2

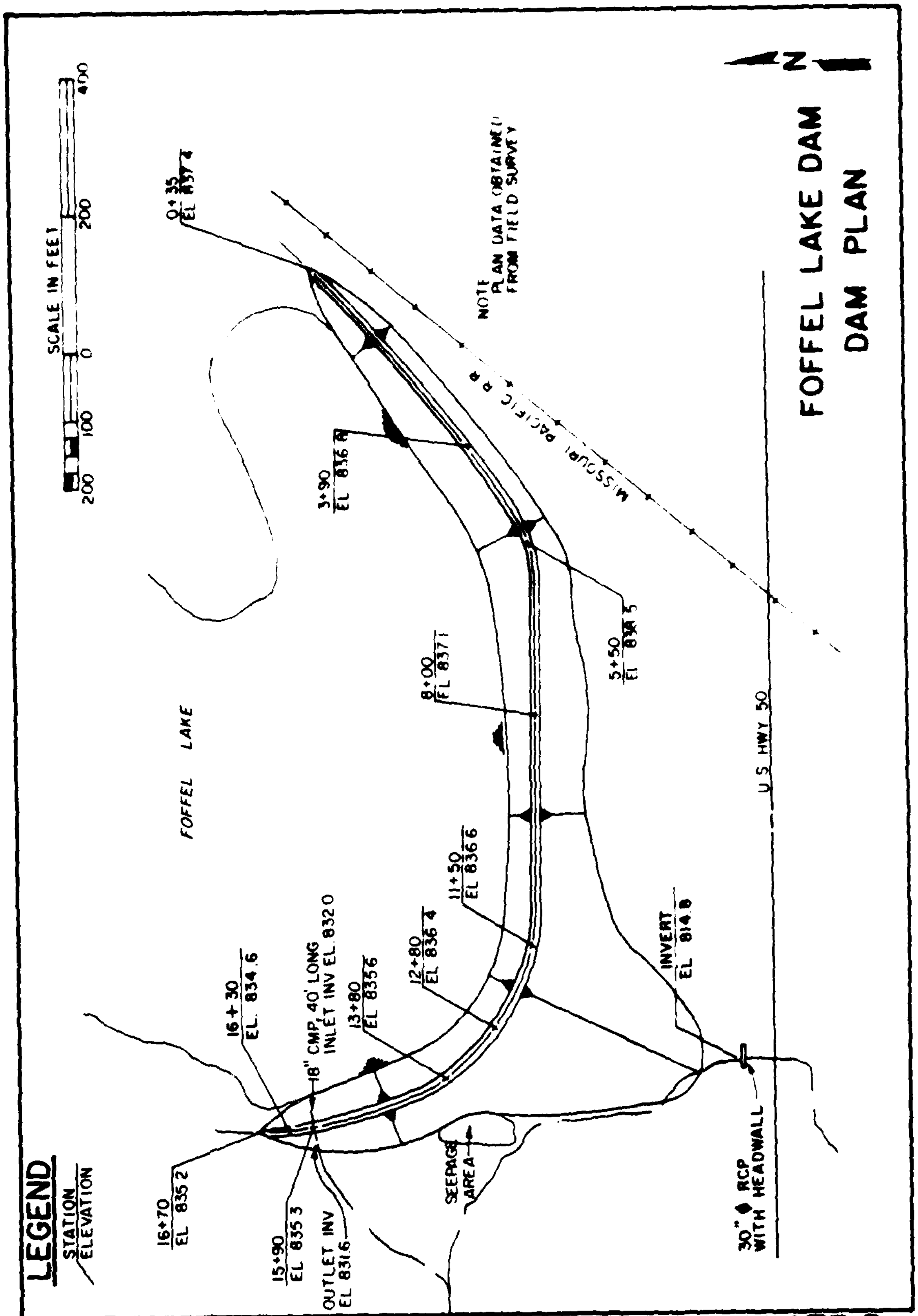
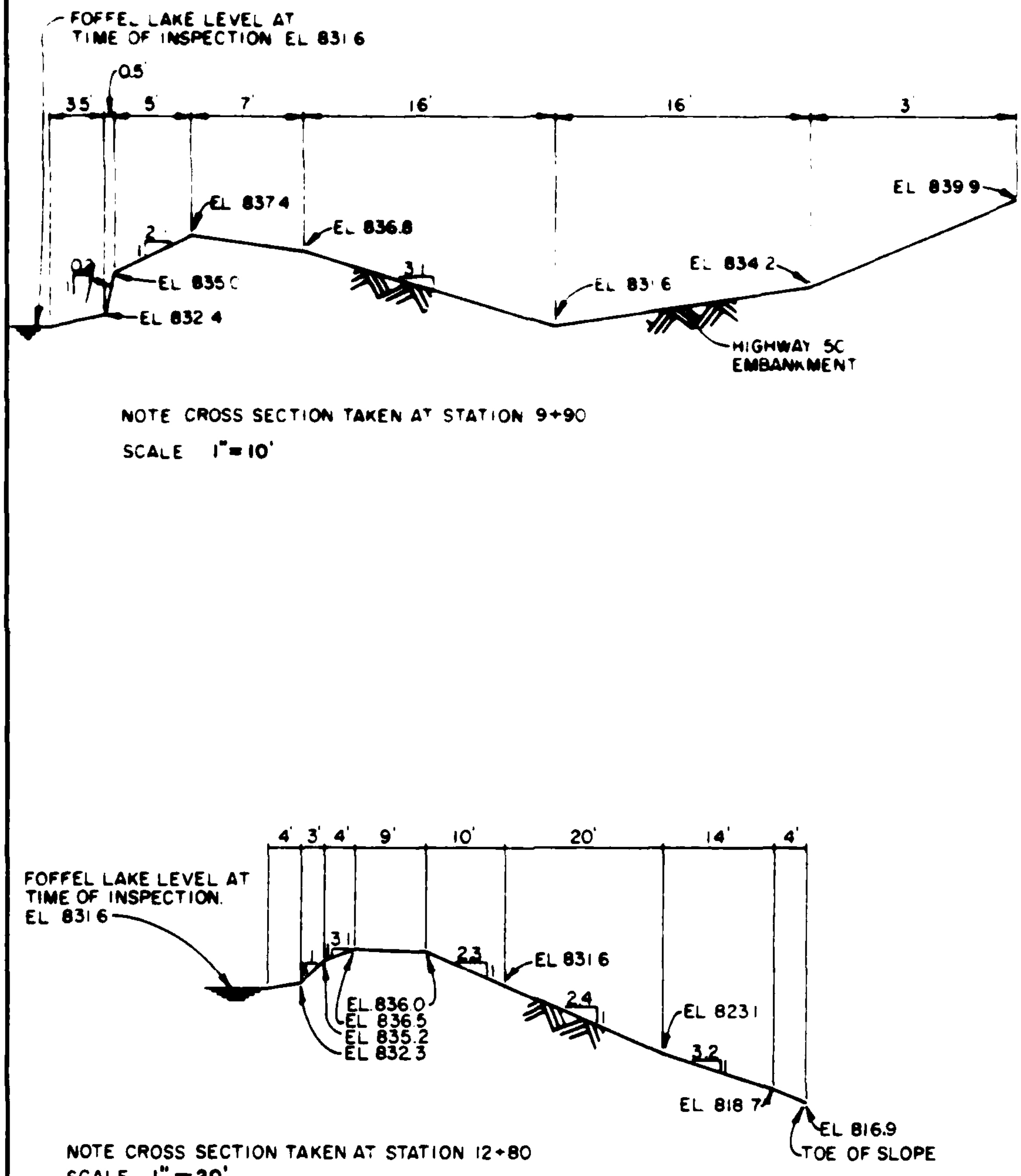

FOFFEL LAKE DAM
DAM PLAN
LEGEND
STATION
ELEVATION
SCALE IN FEET
200
100
0
200
400
NOTE
PLAN DATA OBTAINED FROM FIELD SURVEY
FOFFEL LAKE
MISSOURI PACIFIC R R
U S HWY 50
0+35
3+90
5+50
8+00
11+50
EL 836.6
12+80
13+80
EL 835.6
16+30
EL. 834.6
16+70
EL 835.2
15+90
EL 835.3
18" CMP, 40' LONG
INLET INV EL 832.0
OUTLET INV
EL 831.6
INVERT
EL 814.8
SEEPAGE AREA
30" ϕ RCP
WITH HEADWALL

PLATE 3



FOFFEL LAKE DAM
DAM CROSS SECTIONS

PLATE 4

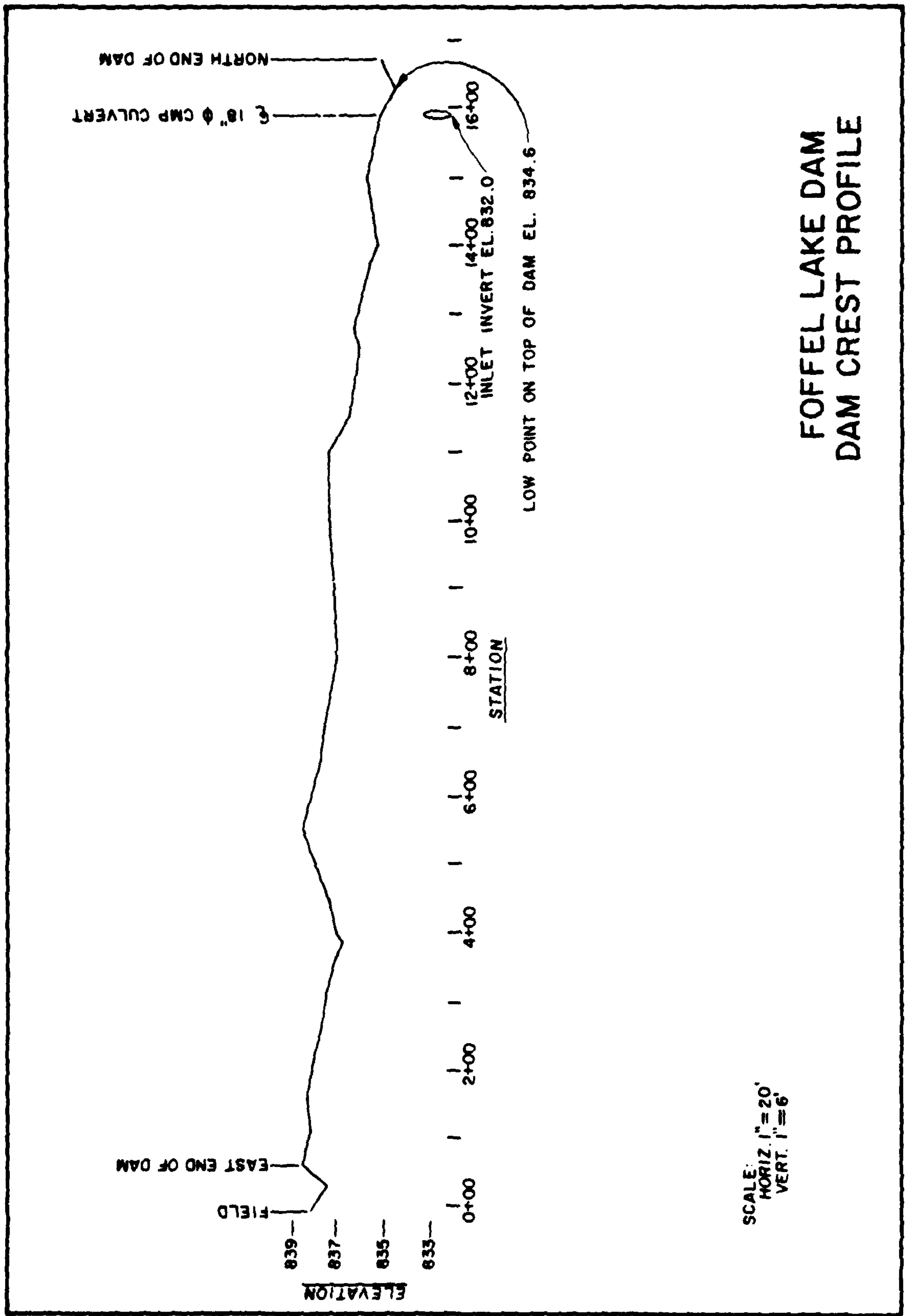

FOFFEL LAKE DAM
DAM CREST PROFILE
NORTH END OF DAM
℄ 18" ϕ CMP CULVERT
INLET INVERT EL. 832.0
LOW POINT ON TOP OF DAM EL. 834.6
EAST END OF DAM
FIELD
ELEVATION
839
837
835
833
STATION
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
SCALE:
HORIZ. 1"=20'
VERT. 1"=6'

PLATE 5

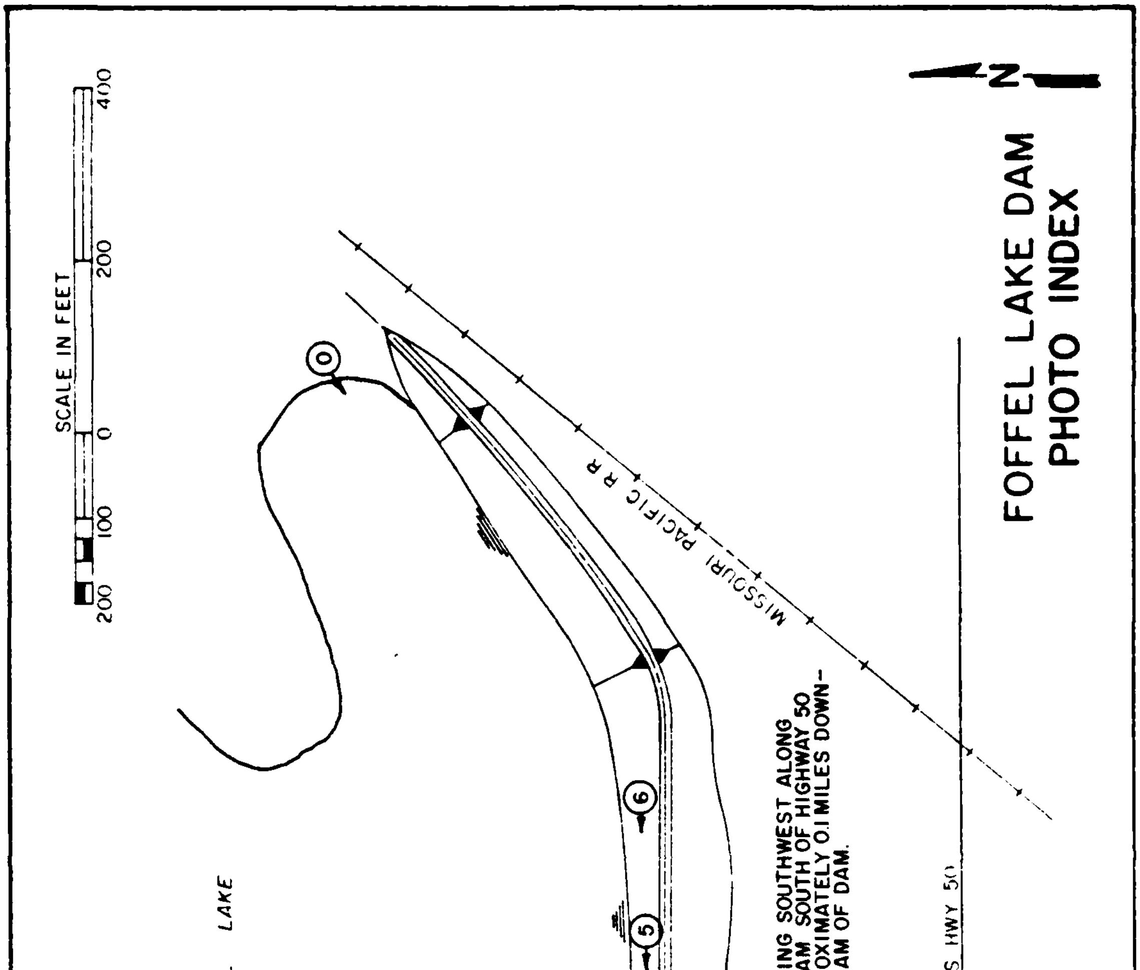

FOFFEL LAKE DAM
PHOTO INDEX
LEGEND
PHOTO NO. & DIRECTION
SCALE IN FEET
200
100
0
200
400
N
MISSOURI PACIFIC R R
FOFFEL LAKE
U S HWY 50
PHOTO 22: LOOKING SOUTHWEST ALONG STREAM SOUTH OF HIGHWAY 50 APPROXIMATELY 0.1 MILES DOWN-STREAM OF DAM.
18" CMP, 40' LONG
30" ⌀ RCP WITH HEADWALL
SEEPAGE AREA

PLATE 6

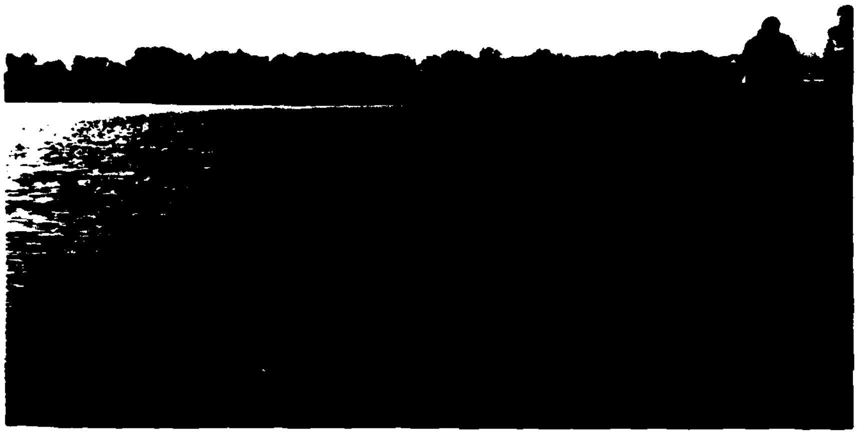


PHOTO 1: UPSTREAM FACE OF DAM LOOKING WEST

PHOTO : UPSTREAM FACE OF DAM LOOKING NORTH

PHOTO 3: CREST OF DAM LOOKING SOUTH

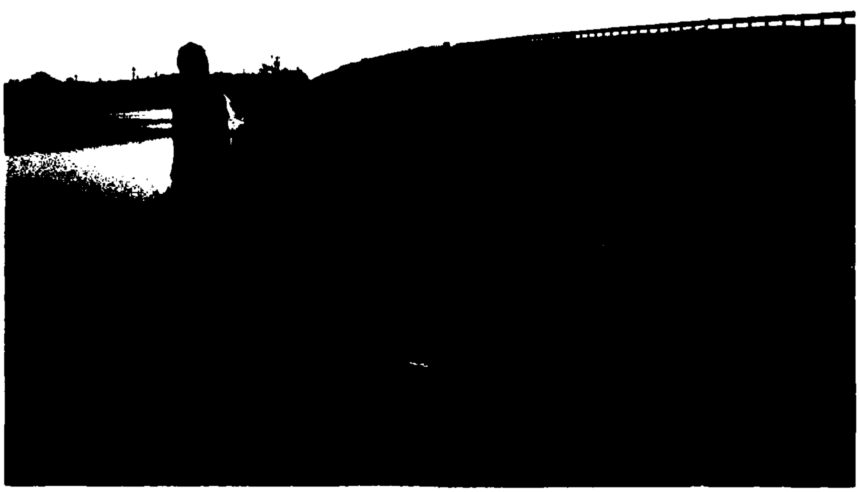


PHOTO 4: CREST OF DAM LOOKING EAST

PHOTO 5: CREST OF DAM LOOKING WEST

PHOTO 6: CREST OF DAM LOOKING WEST FROM EAST END

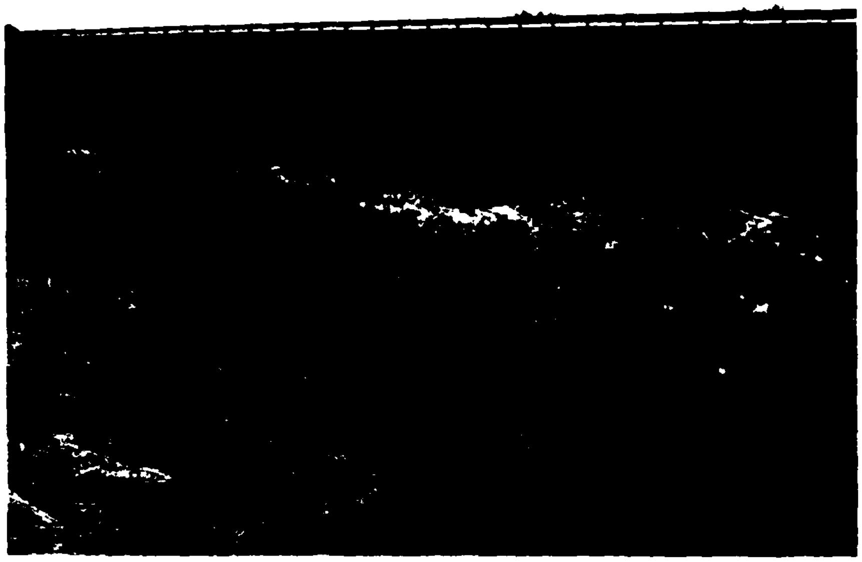


PHOTO 7: DOWNSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 8: DOWNSTREAM FACE OF DAM LOOKING WEST

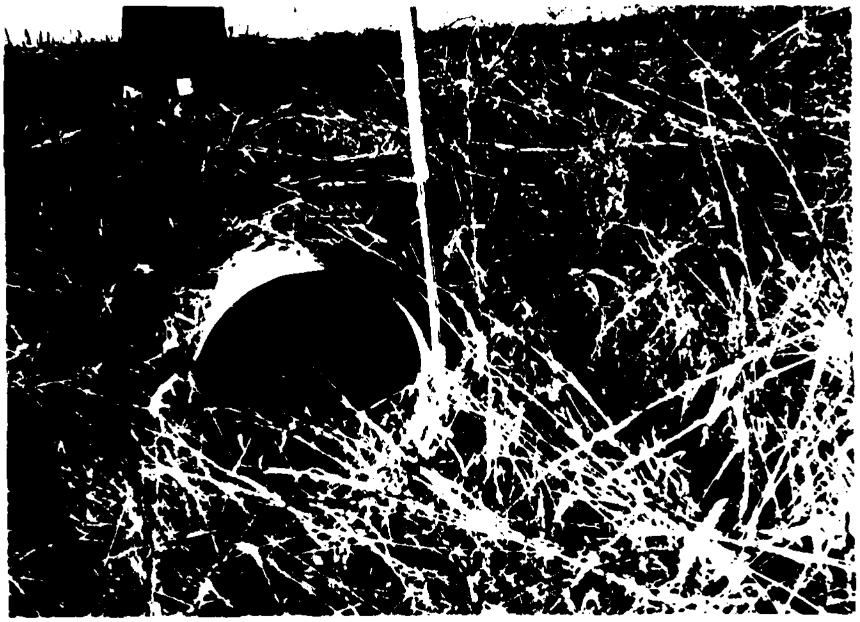


PHOTO 9: UPSTREAM END OF SPILLWAY PIPE

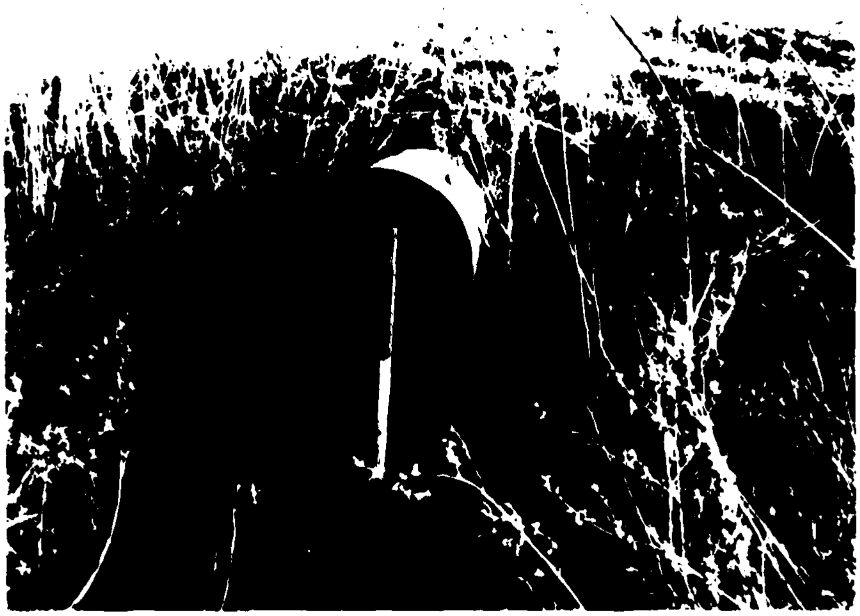


PHOTO 10: DOWNSTREAM END OF SPILLWAY PIPE

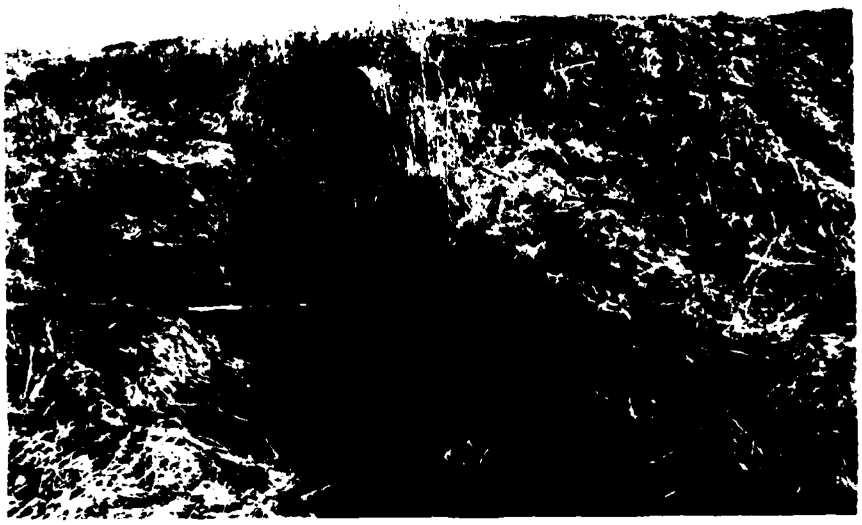


PHOTO 11: CHANNEL DOWNSTREAM OF SPILLWAY PIPE OUTLET

PHOTO 12: DITCH ALONG DOWNSTREAM TOE OF DAM

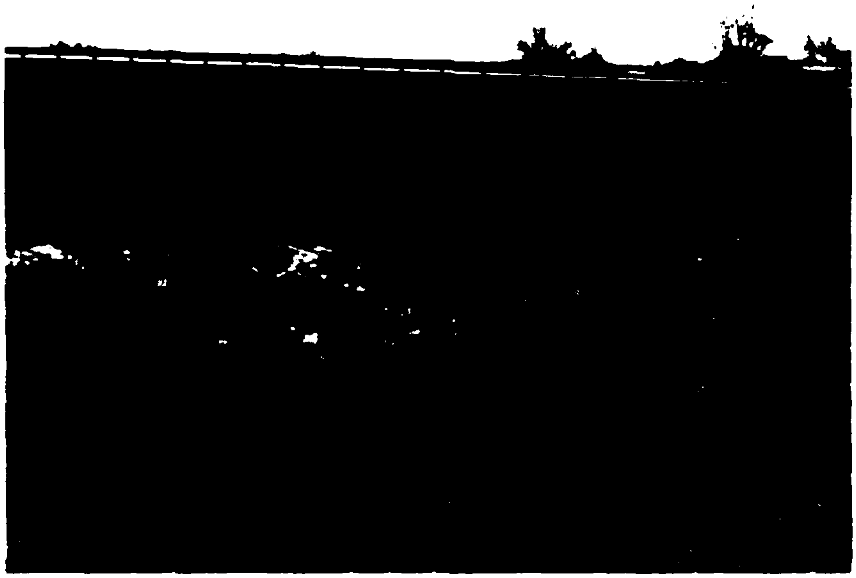


PHOTO 13: DITCH TO HIGHWAY CULVERT INLET

[illegible] HIGHWAY CULVERT

PHOTO 15: OUTLET FROM HIGHWAY CULVERT

PHOTO 16: AREA DOWNSTREAM OF HIGHWAY CULVERT

PHOTO 17: SEEPAGE AREA AT DOWNSTREAM TOE OF DAM

PHOTO 18: NEAR VERTICAL UPSTREAM FACE OF DAM DUE TO EROSION
AND SLOUGHING

PHOTO 19: EROSION AND SLOUGHING OF UPSTREAM FACE OF DAM

PHOTO 20: AREA WEST OF DAM VIEWED FROM DAM

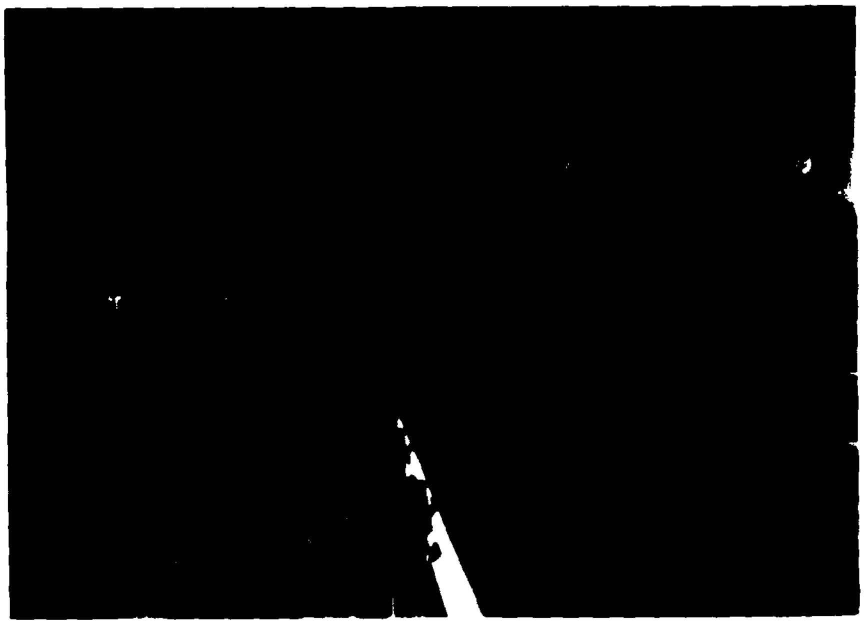


PHOTO 21: LOW POINT ALONG HIGHWAY WEST OF DAM

PHOTO 22: AREA DOWNSTREAM OF HIGHWAY

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety Version) (Reference [illegible]).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33) (Reference 4). Reduction factors were not applied. The rainfall distribution for the 24-hour PMF storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411 (Reference 5). The Sweet Springs, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method (References [illegible] and [illegible]). Time of concentration (T_c) was determined using the "Kirpich" formula and verified by the SCS and Navy methods. The parameters for the unit hydrograph are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for the rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the modified puls method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the inlet invert elevation of the spillway at elevation 83[illegible].0 feet m.s.l. in accordance with antecedent storm conditions AMC II and AMC III preceding the one percent probability and probable maximum storms as outlined by the U.S. Army Corps of Engineers, St. Louis District (Reference 7). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillway is shown in Table 4. The flow over the crest of the dam was determined using the non-level dam crest option ($SL and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

The result of the routing analysis indicates that 25 percent of the PMF will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table [illegible].

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	47 acres
Length of Longest Watercourse (L)	0.22 miles
Elevation Difference in Watershed (H)	83 feet
Lag Time (L_g)	0.05 hours
Time of concentration (T_c)	0.08 hours
Duration (D)	0.7 min. (use 5 minute intervals)

Time (Min.) *	Discharge (cfs) *
0	0
5	388
10	143
15	33
20	7
25	2

* From HEC-1 computer output

FORMULAS USED:

$$T_c = (11.9\ L^3/H)^{0.385}$$

$$L_g = 0.6\ T_c$$

$$D = 0.133\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	32.76	32.14	0.62
1% Probability	24	7.49	5.96	1.53

Additional Data:

1) The soil associations in this watershed are Norris, Deepwater, Sampsel, Snead, and Haig (Reference 1).
   40 percent of drainage area in hydrologic soil group C.
   60 percent of drainage area in hydrologic soil group D.
   33 percent of the land use was grassland.
   67 percent of the land use was cropland.
2) SCS Runoff Curve CN = 95 (AMC III) for the PMF.
3) SCS Runoff Curve CN = 87 (AMC II) for the one percent probability flood (Reference 8).

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*832.0	10.3	48	0
**834.6	15.1	80	7.3

*Spillway Pipe Inlet Invert Elevation
**Top of Dam Elevation

The relationships in Table 3 were developed from the Knob Noster, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft-msl)	Spillway Discharge (cfs)
*832.0	0
832.9	2.5
833.7	5.0
**834.6	7.3

*Spillway Inlet Invert Elevation
**Top of Dam Elevation

METHOD USED:

Spillway release rates were determined by nomographs for corrugated metal pipe culverts with inlet or outlet control (Reference9).

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft.-msl)	Total Storage (ac.-ft.)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam	Duration Over Top of Dam (hrs.)
-	0	*832.0	48	0	-	--
0.25	328	834.3	76	7	0	0
0.50	656	835.4	91	85	0.8	8.5
1.00	1,312	836.2	105	830	1.6	10.7

*Spillway Inlet Invert Elevation

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION  [illegible] APR [illegible]
************************************
   1            A1  MISSOURI DAM INSPECTION PROGRAM
   2            A2  ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
   3            A3  [illegible] LAKE DAM  ([illegible])
   4            B    [illegible]     [illegible]     [illegible]     [illegible]     [illegible]     [illegible]     [illegible]     [illegible]     [illegible]     [illegible]
   5            B1     [illegible]
   6            J      1        [illegible]       1
   7            J1   .[illegible]      .[illegible]      .35      .4      .45      .[illegible]      .55      .[illegible]      [illegible]
   8            K      [illegible]        1                                          [illegible]      1
   9            K1   [illegible] LAKE (26 HR. PROBABLE MAXIMUM [illegible])
  10            M      1        2       .[illegible]74                               1
  11            P              [illegible].2      [illegible]      1[illegible]      13[illegible]
  12            T                                                                            -1      -95
  13            W[illegible]           .[illegible]
  14            A                     1
  15            K      1        2                                                        1
  16            K1   FLOW THROUGH SPILLWAY
  17            Y                                         1        1
  18            Y1     1                                                              -[illegible]2.      -1
  19            Y4   [illegible]      [illegible].7      [illegible]      [illegible]      [illegible].2      [illegible].5      [illegible]      [illegible]      [illegible]
  20            Y4 [illegible]34.[illegible]      [illegible]      [illegible]      [illegible]      [illegible]      [illegible]41.
  21            Y5     0.      1.9      2.5      2.9      [illegible]      4.2      4.[illegible]       5.      5.[illegible]6.4
  22            Y5     [illegible]      [illegible]      [illegible]      11.[illegible]      1[illegible]      1[illegible]
  23            $A     [illegible]      1[illegible]      2[illegible]
  24            $E   [illegible]      [illegible]      [illegible]
  25            $[illegible]   [illegible]
  26            $[illegible] [illegible]34.[illegible]
  27            $L     [illegible]      [illegible]      [illegible]      [illegible]      [illegible]      77[illegible]      [illegible]      1[illegible]      [illegible]
  28            $V [illegible]      [illegible]      [illegible]      [illegible]      [illegible]      [illegible]      [illegible]37.4      [illegible]37.5      [illegible]
  29            K     99
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 L A C K   & V E A T C H                                                              PROJECT 9472:      DATE  JAN  79    PAGE    4
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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
 LAST MODIFICATION  01 APR 80
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                    MISSOURI DAM INSPECTION PROGRAM
                    ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
                    FOFFEL LAKE DAM  (DMF)

                                        JOB SPECIFICATION
                    NQ      NHR      NMIN      IDAY      IHR      IMIN     METRC    IPLT     IPRT    NSTAN
                    288       0         5         0        0        0        0        0        0        0
                                             JOPER      NWT     LROPT    TRACE
                                                5         0        0        0

                                     MULTI-PLAN ANALYSES TO BE PERFORMED
                                        NPLAN= 1 NRTIO= 9 LRTIO= 1
                       RTIOS=     .25      .30      .35      .40      .45      .50      .55      .60    1.00

                ***********         ***********         ***********         ***********         ***********

                                         SUB-AREA RUNOFF COMPUTATION

                      FOFFEL LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)

                              ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT    INAME   ISTAGE   IAUTO
                                 1        0        0        0        0       3        1        0        0

                                          HYDROGRAPH DATA
                    IHYDG    IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                        1       2      .07      .00      .07     1.00     .000        0        0        0

                                          PRECIP DATA
                              SPFE      PMS       R6      R12      R24      R48      R72      R96
                               .00    25.25   101.00   120.00   130.00      .00      .00      .00

                                          LOSS DATA
                 LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                     0     .00     .00    1.00     .00     .00    1.00   -1.00  -95.00     .00     .00

                    CURVE NO =  -95.00  WETNESS =   -1.00  EFFECT CN =   95.00

                                          UNIT HYDROGRAPH DATA
                                        TC=     .00     LAG=    .05

                                          RECESSION DATA
                                  STRTQ=     .00    QRCSN=     .00    RTIOR= 1.00

                    TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

                   UNIT HYDROGRAPH  5 END OF PERIOD ORDINATES, TC=      .00 HOURS, LAG=     .05   VOL= 1.00
                 ???.       14?.         3?.          ?.           ?.
```

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.21	.21	.00	74.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.21	.21	.00	111.
1.01	.15	3	.01	.00	.01	0.	1.01	12.15	147	.21	.21	.00	115.
1.01	.20	4	.01	.00	.01	0.	1.01	12.20	148	.21	.21	.00	121.
1.01	.25	5	.01	.00	.01	0.	1.01	12.25	149	.21	.21	.00	[illegible]
1.01	.30	6	.01	.00	.01	0.	1.01	12.30	150	.21	.21	.00	[illegible]
1.01	.35	7	.01	.00	.01	0.	1.01	12.35	151	.21	.21	.00	[illegible]
1.01	.40	8	.01	.00	.01	0.	1.01	12.40	152	.21	.21	.00	[illegible]
1.01	.45	9	.01	.00	.01	0.	1.01	12.45	153	.21	.21	.00	[illegible]
1.01	.50	10	.01	.00	.01	1.	1.01	12.50	154	.21	.21	.00	[illegible]
1.01	.55	11	.01	.00	.01	1.	1.01	12.55	155	.21	.21	.00	[illegible]
1.01	1.00	12	.01	.00	.01	1.	1.01	13.00	156	.21	.21	.00	[illegible]
1.01	1.05	13	.01	.00	.01	2.	1.01	13.05	157	.25	.25	.00	137.
1.01	1.10	14	.01	.00	.01	2.	1.01	13.10	158	.25	.25	.00	[illegible]
1.01	1.15	15	.01	.00	.01	2.	1.01	13.15	159	.25	.25	.00	[illegible]
1.01	1.20	16	.01	.00	.01	2.	1.01	13.20	160	.25	.25	.00	[illegible]
1.01	1.25	17	.01	.00	.01	3.	1.01	13.25	161	.25	.25	.00	[illegible]
1.01	1.30	18	.01	.01	.01	3.	1.01	13.30	162	.25	.25	.00	[illegible]
1.01	1.35	19	.01	.01	.01	3.	1.01	13.35	163	.25	.25	.00	[illegible]
1.01	1.40	20	.01	.01	.01	3.	1.01	13.40	164	.25	.25	.00	[illegible]
1.01	1.45	21	.01	.01	.01	4.	1.01	13.45	165	.25	.25	.00	[illegible]
1.01	1.50	22	.01	.01	.01	4.	1.01	13.50	166	.25	.25	.00	[illegible]
1.01	1.55	23	.01	.01	.01	4.	1.01	13.55	167	.25	.25	.00	[illegible]
1.01	2.00	24	.01	.01	.01	4.	1.01	14.00	168	.25	.25	.00	[illegible]
1.01	2.05	25	.01	.01	.01	4.	1.01	14.05	169	.32	.32	.00	[illegible]
1.01	2.10	26	.01	.01	.01	4.	1.01	14.10	170	.32	.32	.00	[illegible]
1.01	2.15	27	.01	.01	.01	4.	1.01	14.15	171	.32	.32	.00	[illegible]
1.01	2.20	28	.01	.01	.01	5.	1.01	14.20	172	.32	.32	.00	[illegible]
1.01	2.25	29	.01	.01	.01	5.	1.01	14.25	173	.32	.32	.00	[illegible]
1.01	2.30	30	.01	.01	.01	5.	1.01	14.30	174	.32	.32	.00	[illegible]
1.01	2.35	31	.01	.01	.01	5.	1.01	14.35	175	.32	.32	.00	[illegible]
1.01	2.40	32	.01	.01	.01	5.	1.01	14.40	176	.32	.32	.00	[illegible]
1.01	2.45	33	.01	.01	.01	5.	1.01	14.45	177	.32	.32	.00	[illegible]
1.01	2.50	34	.01	.01	.00	5.	1.01	14.50	178	.32	.32	.00	[illegible]
1.01	2.55	35	.01	.01	.00	5.	1.01	14.55	179	.32	.32	.00	[illegible]
1.01	3.00	36	.01	.01	.00	5.	1.01	15.00	180	.32	.32	.00	[illegible]
1.01	3.05	37	.01	.01	.00	5.	1.01	15.05	181	.19	.19	.00	174.
1.01	3.10	38	.01	.01	.00	6.	1.01	15.10	182	.39	.39	.00	171.
1.01	3.15	39	.01	.01	.00	6.	1.01	15.15	183	.39	.39	.00	[illegible]
1.01	3.20	40	.01	.01	.00	6.	1.01	15.20	184	.59	.59	.00	[illegible]
1.01	3.25	41	.01	.01	.00	6.	1.01	15.25	185	.68	.68	.00	[illegible]
1.01	3.30	42	.01	.01	.00	6.	1.01	15.30	186	1.64	1.64	.00	[illegible]
1.01	3.35	43	.01	.01	.00	6.	1.01	15.35	187	2.71	2.71	.00	[illegible]
1.01	3.40	44	.01	.01	.00	6.	1.01	15.40	188	1.06	1.06	.00	[illegible]
1.01	3.45	45	.01	.01	.00	6.	1.01	15.45	189	.68	.68	.00	[illegible]
1.01	3.50	46	.01	.01	.00	6.	1.01	15.50	190	.58	.58	.00	[illegible]
1.01	3.55	47	.01	.01	.00	6.	1.01	15.55	191	.39	.39	.00	267.
1.01	4.00	48	.01	.01	.00	6.	1.01	16.00	192	.39	.39	.00	[illegible]
1.01	4.05	49	.01	.01	.00	6.	1.01	16.05	193	.30	.30	.00	[illegible]
1.01	4.10	50	.01	.01	.00	6.	1.01	16.10	194	.30	.30	.00	174.
1.01	4.15	51	.01	.01	.00	6.	1.01	16.15	195	.30	.30	.00	171.
1.01	4.20	52	.01	.01	.00	6.	1.01	16.20	196	.30	.30	.00	[illegible]
1.01	4.25	53	.01	.01	.00	6.	1.01	16.25	197	.30	.30	.00	[illegible]

1.01	4.30	54	.01	.01	.00	6.	1.01	16.30	198	.30	.30	.00	170.
1.01	4.35	55	.01	.01	.00	6.	1.01	16.35	199	.30	.30	.00	170.
1.01	4.40	56	.01	.01	.00	6.	1.01	16.40	200	.30	.30	.00	170.
1.01	4.45	57	.01	.01	.00	6.	1.01	16.45	201	.30	.30	.00	170.
1.01	4.50	58	.01	.01	.00	7.	1.01	16.50	202	.30	.30	.00	170.
1.01	4.55	59	.01	.01	.00	7.	1.01	16.55	203	.30	.30	.00	170.
1.01	5.00	60	.01	.01	.00	7.	1.01	17.00	204	.30	.30	.00	170.
1.01	5.05	61	.01	.01	.00	7.	1.01	17.05	205	.23	.23	.00	14[illegible].
1.01	5.10	62	.01	.01	.00	7.	1.01	17.10	206	.23	.23	.00	1[illegible].
1.01	5.15	63	.01	.01	.00	7.	1.01	17.15	207	.23	.23	.00	134.
1.01	5.20	64	.01	.01	.00	7.	1.01	17.20	208	.23	.23	.00	134.
1.01	5.25	65	.01	.01	.00	7.	1.01	17.25	209	.23	.23	.00	134.
1.01	5.30	66	.01	.01	.00	7.	1.01	17.30	210	.23	.23	.00	134.
1.01	5.35	67	.01	.01	.00	7.	1.01	17.35	211	.23	.23	.00	134.
1.01	5.40	68	.01	.01	.00	7.	1.01	17.40	212	.23	.23	.00	134.
1.01	5.45	69	.01	.01	.00	7.	1.01	17.45	213	.23	.23	.00	134.
1.01	5.50	70	.01	.01	.00	7.	1.01	17.50	214	.23	.23	.00	134.
1.01	5.55	71	.01	.01	.00	7.	1.01	17.55	215	.23	.23	.00	134.
1.01	6.00	72	.01	.01	.00	7.	1.01	18.00	216	.23	.23	.00	134.
1.01	6.05	73	.07	.06	.01	7[illegible].	1.01	18.05	217	.02	.02	.00	51.
1.01	6.10	74	.07	.06	.01	7[illegible].	1.01	18.10	218	.02	.02	.00	21.
1.01	6.15	75	.07	.06	.01	7[illegible].	1.01	18.15	219	.02	.02	.00	14.
1.01	6.20	76	.07	.06	.01	74.	1.01	18.20	220	.02	.02	.00	1[illegible].
1.01	6.25	77	.07	.06	.01	74.	1.01	18.25	221	.02	.02	.00	[illegible].
1.01	6.30	78	.07	.06	.01	75.	1.01	18.30	222	.02	.02	.00	1[illegible].
1.01	6.35	79	.07	.06	.01	75.	1.01	18.35	223	.02	.02	.00	12.
1.01	6.40	80	.07	.06	.00	75.	1.01	18.40	224	.02	.02	.00	12.
1.01	6.45	81	.07	.06	.00	7[illegible].	1.01	18.45	225	.02	.02	.00	12.
1.01	6.50	82	.07	.06	.00	76.	1.01	18.50	226	.02	.02	.00	12.
1.01	6.55	83	.07	.06	.00	76.	1.01	18.55	227	.02	.02	.00	12.
1.01	7.00	84	.07	.06	.00	76.	1.01	19.00	228	.02	.02	.00	12.
1.01	7.05	85	.07	.06	.00	76.	1.01	19.05	229	.02	.02	.00	12.
1.01	7.10	86	.07	.06	.00	76.	1.01	19.10	230	.02	.02	.00	12.
1.01	7.15	87	.07	.06	.00	76.	1.01	19.15	231	.02	.02	.00	12.
1.01	7.20	88	.07	.06	.00	76.	1.01	19.20	232	.02	.02	.00	12.
1.01	7.25	89	.07	.06	.00	76.	1.01	19.25	233	.02	.02	.00	12.
1.01	7.30	90	.07	.06	.00	76.	1.01	19.30	234	.02	.02	.00	12.
1.01	7.35	91	.07	.06	.00	77.	1.01	19.35	235	.02	.02	.00	12.
1.01	7.40	92	.07	.06	.00	77.	1.01	19.40	236	.02	.02	.00	12.
1.01	7.45	93	.07	.06	.00	77.	1.01	19.45	237	.02	.02	.00	12.
1.01	7.50	94	.07	.06	.00	77.	1.01	19.50	238	.02	.02	.00	12.
1.01	7.55	95	.07	.06	.00	77.	1.01	19.55	239	.02	.02	.00	12.
1.01	8.00	96	.07	.06	.00	77.	1.01	20.00	240	.02	.02	.00	12.
1.01	8.05	97	.07	.06	.00	77.	1.01	20.05	241	.02	.02	.00	12.
1.01	8.10	98	.07	.06	.00	77.	1.01	20.10	242	.02	.02	.00	12.
1.01	8.15	99	.07	.06	.00	77.	1.01	20.15	243	.02	.02	.00	12.
1.01	8.20	100	.07	.06	.00	77.	1.01	20.20	244	.02	.02	.00	12.
1.01	8.25	101	.07	.06	.00	77.	1.01	20.25	245	.02	.02	.00	12.
1.01	8.30	102	.07	.06	.00	77.	1.01	20.30	246	.02	.02	.00	12.
1.01	8.35	103	.07	.06	.00	77.	1.01	20.35	247	.02	.02	.00	12.
1.01	8.40	104	.07	.07	.00	77.	1.01	20.40	248	.02	.02	.00	12.
1.01	8.45	105	.07	.07	.00	77.	1.01	20.45	249	.02	.02	.00	12.
1.01	8.50	106	.07	.07	.00	77.	1.01	20.50	250	.02	.02	.00	12.
1.01	8.55	107	.07	.07	.00	77.	1.01	20.55	251	.02	.02	.00	12.
1.01	9.00	108	.07	.07	.00	77.	1.01	21.00	252	.02	.02	.00	12.
1.01	9.05	109	.07	.07	.00	77.	1.01	21.05	253	.02	.02	.00	12.

1.01	9.10	110	.07	.07	.00	37.	1.01	21.10	254	.02	.02	.00	[illegible]
1.01	9.15	111	.07	.07	.00	37.	1.01	21.15	255	.02	.02	.00	[illegible]
1.01	9.20	112	.07	.07	.00	37.	1.01	21.20	256	.02	.02	.00	[illegible]
1.01	9.25	113	.07	.07	.00	37.	1.01	21.25	257	.02	.02	.00	[illegible]
1.01	9.30	114	.07	.07	.00	37.	1.01	21.30	258	.02	.02	.00	[illegible]
1.01	9.35	115	.07	.07	.00	37.	1.01	21.35	259	.02	.02	.00	[illegible]
1.01	9.40	116	.07	.07	.00	38.	1.01	21.40	260	.02	.02	.00	[illegible]
1.01	9.45	117	.07	.07	.00	38.	1.01	21.45	261	.02	.02	.00	[illegible]
1.01	9.50	118	.07	.07	.00	38.	1.01	21.50	262	.02	.02	.00	[illegible]
1.01	9.55	119	.07	.07	.00	38.	1.01	21.55	263	.02	.02	.00	[illegible]
1.01	10.00	120	.07	.07	.00	38.	1.01	22.00	264	.02	.02	.00	[illegible]
1.01	10.05	121	.07	.07	.00	38.	1.01	22.05	265	.02	.02	.00	[illegible]
1.01	10.10	122	.07	.07	.00	38.	1.01	22.10	266	.02	.02	.00	[illegible]
1.01	10.15	123	.07	.07	.00	38.	1.01	22.15	267	.02	.02	.00	[illegible]
1.01	10.20	124	.07	.07	.00	38.	1.01	22.20	268	.02	.02	.00	[illegible]
1.01	10.25	125	.07	.07	.00	38.	1.01	22.25	269	.02	.02	.00	[illegible]
1.01	10.30	126	.07	.07	.00	38.	1.01	22.30	270	.02	.02	.00	[illegible]
1.01	10.35	127	.07	.07	.00	38.	1.01	22.35	271	.02	.02	.00	[illegible]
1.01	10.40	128	.07	.07	.00	38.	1.01	22.40	272	.02	.02	.00	[illegible]
1.01	10.45	129	.07	.07	.00	38.	1.01	22.45	273	.02	.02	.00	[illegible]
1.01	10.50	130	.07	.07	.00	38.	1.01	22.50	274	.02	.02	.00	[illegible]
1.01	10.55	131	.07	.07	.00	38.	1.01	22.55	275	.02	.02	.00	[illegible]
1.01	11.00	132	.07	.07	.00	38.	1.01	23.00	276	.02	.02	.00	[illegible]
1.01	11.05	133	.07	.07	.00	38.	1.01	23.05	277	.02	.02	.00	[illegible]
1.01	11.10	134	.07	.07	.00	38.	1.01	23.10	278	.02	.02	.00	[illegible]
1.01	11.15	135	.07	.07	.00	38.	1.01	23.15	279	.02	.02	.00	[illegible]
1.01	11.20	136	.07	.07	.00	38.	1.01	23.20	280	.02	.02	.00	[illegible]
1.01	11.25	137	.07	.07	.00	38.	1.01	23.25	281	.02	.02	.00	[illegible]
1.01	11.30	138	.07	.07	.00	38.	1.01	23.30	282	.02	.02	.00	[illegible]
1.01	11.35	139	.07	.07	.00	38.	1.01	23.35	283	.02	.02	.00	[illegible]
1.01	11.40	140	.07	.07	.00	38.	1.01	23.40	284	.02	.02	.00	[illegible]
1.01	11.45	141	.07	.07	.00	38.	1.01	23.45	285	.02	.02	.00	[illegible]
1.01	11.50	142	.07	.07	.00	38.	1.01	23.50	286	.02	.02	.00	[illegible]
1.01	11.55	143	.07	.07	.00	38.	1.01	23.55	287	.02	.02	.00	[illegible]
1.01	12.00	144	.07	.07	.00	38.	1.02	.00	288	.02	.02	.00	[illegible]

SUM [illegible] 32.14 [illegible] [illegible]
(8[illegible]2.)(816.)(16.)([illegible])

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1212.	201.	64.	64.	16396.
CMS	27.	6.	2.	2.	[illegible]
INCHES		25.31	32.12	32.12	32.1[illegible]
MM		642.87	815.79	815.79	[illegible]
AC-FT		100.	127.	127.	127.
THOUS CU M		123.	156.	156.	15[illegible].

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3[illegible].	[illegible].	16.	16.	45[illegible].
CMS	9.	1.	0.	0.	13[illegible].
INCHES		[illegible]	8.0[illegible]	8.0[illegible]	[illegible]
MM		1[illegible].77	203.95	203.95	203.95

CFS	656.	161.	32.	32.	9195.
CMS	19.	3.	1.	1.	260.
INCHES		12.65	16.06	16.06	16.06
MM		321.43	407.89	407.89	407.89
AC-FT		50.	63.	63.	63.
THOUS CU M		62.	78.	78.	78.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	732.	141.	35.	35.	10318.
CMS	20.	3.	1.	1.	288.
INCHES		13.92	17.66	17.66	17.66
MM		353.58	448.68	448.68	448.68
AC-FT		55.	70.	70.	70.
THOUS CU M		68.	86.	86.	86.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	797.	121.	38.	38.	11037.
CMS	22.	3.	1.	1.	313.
INCHES		15.19	19.27	19.27	19.27
MM		385.72	489.47	489.47	489.47
AC-FT		60.	76.	76.	76.
THOUS CU M		74.	94.	94.	94.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1312.	201.	64.	64.	18390.
CMS	37.	6.	2.	2.	521.
INCHES		25.31	32.12	32.12	32.12
MM		642.87	815.79	815.79	815.79
AC-FT		100.	127.	127.	127.
THOUS CU M		123.	156.	156.	156.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THROUGH SPILLWAY

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
.0	.000	.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.000	.000	.000	-932.	-1

STAGE	932.00	932.70	932.90	933.00	933.20	933.50	933.40	933.70	[illegible]	[illegible]
	934.30	935.00	936.50	938.00	939.50	941.00				
FLOW	.00	1.90	2.50	2.90	3.70	4.20	4.60	5.00	5.[illegible]	[illegible]
	4.80	8.00	9.50	11.10	12.30	13.90				

SURFACE AREA=	0.	19.	25.
CAPACITY=	0.	42.	184.
ELEVATION=	912.	932.	940.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
874.0	.0	.0	.0	.0	.0	.0	.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
874.4	.0	.0	0.

CREST LENGTH	0.	96.	430.	450.	660.	770.	1210.	1390.	2030.	[illegible]
AT OR BELOW ELEVATION	874.4	875.1	875.9	876.1	876.4	876.8	877.4	877.5	878.5	[illegible]

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	6.
6.	6.	6.	6.	6.	6.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.

H E C - 1   V E R S I O N

[illegible] HYDROGRAPH PACKAGE - HEC-1

PROJECT [illegible]   DATE [illegible] JAN [illegible]   PAGE [illegible]

PROGRAM H21722-1V   TIME [illegible]   CASE [illegible]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	[illegible]	1[illegible].	46.	46.	131[illegible].
CMS	24.	5.	1.	1.	[illegible]77.
INCHES		[illegible]	22.92	22.92	22.92
MM		5[illegible].7[illegible]	582.22	582.22	587.22
AC-FT		[illegible]1.	90.	90.	9[illegible].
THOUS CU M		10[illegible].	114.	112.	112.

PEAK [illegible] AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .25	RATIO 2 .30	RATIO 3 .35	RATIO 4 .40	RATIO 5 .45	RATIO 6 .50	RATIO 7 .55	RATIO [illegible] .6[illegible]	RATIO [illegible] 1.[illegible]
HYDROGRAPH AT	[illegible]	.07	1	[illegible].	[illegible].	459.	525.	59[illegible].	[illegible].	7[illegible].	7[illegible].	1[illegible].
	(	.19)	(	9.29)(	11.1[illegible])(	13.00)(	14.[illegible])(	16.72)(	1[illegible])(	[illegible])(	[illegible])(	[illegible])
ROUTED TO	[illegible]	.07	1	7.	8.	24.	46.	6[illegible].	85.	1[illegible].	[illegible].	9[illegible].
	(	.19)	(	.19)(	.22)(	.6[illegible])(	1.30)(	1.7[illegible])(	2.4[illegible])(	3.[illegible])(	[illegible])(	[illegible])

H E C - 1 [illegible] V E R S I O N   PROJECT [illegible]   DATE [illegible]   PAGE [illegible]

[illegible] HYDROGRAPH [illegible] - [illegible]   [illegible] PROGRAM [illegible]-IV TIME [illegible]:15:44 CASE [illegible]

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	87[illegible]	[illegible]32.00	874.[illegible]
STORAGE	4[illegible].	4[illegible].	[illegible]
OUTFLOW	[illegible].	[illegible].	7.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	874.29	.[illegible]	76.	7.	.[illegible]	16.17	[illegible]
.[illegible]	[illegible]4.[illegible]	.[illegible]	[illegible]1.	[illegible].	4.75	[illegible].17	[illegible]
.[illegible]	[illegible]5.[illegible]	.4[illegible]	[illegible].	[illegible]4.	7.[illegible]3	1[illegible]	[illegible]
.[illegible]	875.16	.5[illegible]	85.	48.	[illegible].33	1[illegible]	[illegible]
.[illegible]5	[illegible]5.[illegible]	.[illegible]	[illegible].	[illegible].	[illegible].42	17.17	[illegible]
.[illegible]	[illegible]5.[illegible]	.7[illegible]	[illegible]1.	[illegible]5.	[illegible]	[illegible]	[illegible]
.55	[illegible]	.[illegible]0	9[illegible].	14[illegible].	[illegible].47	15.[illegible]	[illegible]
.[illegible]	[illegible]5.[illegible]	1.[illegible]4	9[illegible].	21[illegible].	9.[illegible]	15.[illegible]	[illegible]
[illegible]	[illegible]6.15	1.5[illegible]	1[illegible]5.	[illegible]30.	10.[illegible]7	15.67	.[illegible]

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

1	A1	MISSOURI DAM INSPECTION PROGRAM									
2	A2	ST. LOUIS DISTRICT US ARMY CORPS OF ENGR									
3	A3	[illegible] LAKE DAM (100-YR)									
4	B	288	0	5	0	0	0	0	0	0	0
5	B1	5									
6	K	5	1				1	1			
7	K1	[illegible] LAKE (.4 SQ. MI. 100-YEAR INFLOW)									
8	M	0	2	.074							
9	O	288	7.454								
10	O1	.008	.034	.005	.008	.008	.008	.008	.008	.008	.008
11	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
12	O1	.008	.008	.008	.008	.008	.008	[illegible]	.008	.008	.008
13	O1	.008	.008	.008	.008	.008	.008	[illegible]	.008	.008	.008
14	O1	.008	.008	.008	.008	.008	.008	[illegible]	.008	.008	.008
15	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
16	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
17	O1	.008	.008	.016	.016	.016	.016	.016	.016	.016	.016
18	O1	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016
19	O1	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016
20	O1	.016	.016	.016	.016	.016	.016	.016	.016	.024	.024
21	O1	.024	.024	.024	.024	.024	.024	.024	.024	.024	.024
22	O1	.024	.024	.024	.024	.024	.024	.033	.033	.033	.033
23	O1	.033	.033	.069	.065	.069	.069	.069	.069	.134	.134
24	O1	.134	.255	.255	.159	.068	.068	.057	.134	.134	.134
25	O1	.069	.069	.069	.065	.065	.065	.033	.033	.033	.033
26	O1	.033	.033	.024	.024	.024	.024	.024	.024	.024	.024
27	O1	.024	.024	.024	.024	.024	.024	.024	.024	.024	.024
28	O1	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016
29	O1	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016
30	O1	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016
31	O1	.016	.016	.016	.016	.016	.016	.008	.008	.008	.008
32	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
33	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
34	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
35	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
36	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
37	O1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
38	O1	.008	.008	.008	.008	.008	.008	.008	.008		
39	T							-1	-.07		
40	W2		.049								
41	X			1							
42	K	1	2					1			
43	K1	ROUTE THROUGH SPILLWAY									
44	Y				1						
45	Y1	1						-672.	-1		
46	Y4	832.	832.7	832.5	833.	833.2	833.5	833.6	833.7	837.5874.1	
47	Y4	836.7	835.0	840.5	838.	839.5	841.				
48	Y5	0.	1.5	2.5	2.5	3.7	4.2	4.6	5.	5.76.4	
49	Y5	6.8	8.3	9.8	11.3	12.3	13.3				
50	$A	0.	10.3	20.2							

```
S T A C K   R E L A T I O N                                                    PROJECT 96??:      DATE 25 JAN 8?   PAGE
FL  D HYDROGRAPH PACKAGE - HEC-1                                               PROGRAM ?.3/?2-1?  TIME 1?:??:??   DATE ??

  ?1              SE  ?1?.    872.    843.
  ?               SE  ?72.
  ?               SE  836.?
  ?               SI    0.     70.    470.    490.    690.    770.   1210.   1390.   2070.21??.
  ?               SV  836.?  835.?   835.9   834.1   836.4   836.?   837.4   837.5   83?.?84?.
  ?               ?    55
  7               A
  ?               A
  ?               A
  ?               A
  ?1              A
```

HORNER & SHIFRIN

FLOOD HYDROGRAPH PACKAGE - HEC-1

PROJECT [illegible] DATE [illegible]

PROGRAM [illegible] TIME [illegible]

****

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

****

MISSOURI DAM INSPECTION PROGRAM
ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
FOFFEL LAKE DAM (100-YR)

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
1	0	0	0

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

FOFFEL LAKE (24 HR, 100-YEAR INFLOW)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	3	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	0	.07	.00	.07	.00	.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
288	7.45	.00	.00

PRECIP PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.03	.02	.03	.03	.03	[illegible]
.03	[illegible]	.07	.07	.07	.07	.07	.07	[illegible]	[illegible]
.13	.23	[illegible]	.16	[illegible]	[illegible]	.25	.13	[illegible]	.11
.07	.07	.07	.07	.07	.07	.03	.03	[illegible]	[illegible]
[illegible]	[illegible]	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.01	.01	.01	.01

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01		

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	.00	.00	1.00	.00	.00	1.00	-1.00	-87.00	.00	.00

CURVE NO = -87.00 WETNESS = -1.00 EFFECT CN = 87.00

UNIT HYDROGRAPH DATA
TC= .00 LAG= .05

RECESSION DATA
STRTQ= .00 QRCSN= .00 RTIOR= 1.00

TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= .00 HOURS, LAG= .05 VOL= 1.00
789. 143. 37. 7. 2.

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.85	.78	.07	582.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.59	.76	.03	271.
1.01	.15	3	.01	.00	.01	0.	1.01	12.15	147	.26	.24	.02	175.
1.01	.20	4	.01	.00	.01	0.	1.01	12.20	148	.13	.13	.01	102.
1.01	.25	5	.01	.00	.01	0.	1.01	12.25	149	.13	.13	.01	79.
1.01	.30	6	.01	.00	.01	0.	1.01	12.30	150	.13	.13	.01	74.
1.01	.35	7	.01	.00	.01	0.	1.01	12.35	151	.07	.07	.00	49.
1.01	.40	8	.01	.00	.01	0.	1.01	12.40	152	.07	.07	.00	41.
1.01	.45	9	.01	.00	.01	0.	1.01	12.45	153	.07	.07	.00	[illegible]
1.01	.50	10	.01	.00	.01	0.	1.01	12.50	154	.07	.07	.00	38.
1.01	.55	11	.01	.00	.01	0.	1.01	12.55	155	.07	.07	.00	38.
1.01	1.00	12	.01	.00	.01	0.	1.01	13.00	156	.07	.07	.00	[illegible]
1.01	1.05	13	.01	.00	.01	0.	1.01	13.05	157	.03	.03	.00	24.
1.01	1.10	14	.01	.00	.01	0.	1.01	13.10	158	.03	.03	.00	[illegible]
1.01	1.15	15	.01	.00	.01	0.	1.01	13.15	159	.03	.03	.00	1[illegible].
1.01	1.20	16	.01	.00	.01	0.	1.01	13.20	160	.03	.03	.00	1[illegible].
1.01	1.25	17	.01	.00	.01	0.	1.01	13.25	161	.03	.03	.00	1[illegible].
1.01	1.30	18	.01	.00	.01	0.	1.01	13.30	162	.03	.03	.00	1[illegible].
1.01	1.35	19	.01	.00	.01	0.	1.01	13.35	163	.02	.02	.00	15.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.02	.02	.00	14.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.02	.02	.00	1[illegible].
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	.02	.02	.00	13.
1.01	1.55	23	.01	.00	.01	0.	1.01	13.55	167	.02	.02	.00	1[illegible].
1.01	2.00	24	.01	.00	.01	0.	1.01	14.00	168	.02	.02	.00	1[illegible].
1.01	2.05	25	.01	.00	.01	0.	1.01	14.05	169	.02	.02	.00	1[illegible].
1.01	2.10	26	.01	.00	.01	0.	1.01	14.10	170	.02	.02	.00	1[illegible].
1.01	2.15	27	.01	.00	.01	0.	1.01	14.15	171	.02	.02	.00	1[illegible].
1.01	2.20	28	.01	.00	.01	0.	1.01	14.20	172	.02	.02	.00	1[illegible].

1.01	2.25	29	.01	.00	.01	0.	1.01	14.25	173	.02	.02	.00	15.
1.01	2.30	30	.01	.00	.01	0.	1.01	14.30	174	.02	.02	.00	15.
1.01	2.35	31	.01	.00	.01	0.	1.01	14.35	175	.02	.02	.00	14.
1.01	2.40	32	.01	.00	.01	0.	1.01	14.40	176	.02	.02	.00	13.
1.01	2.45	33	.01	.00	.01	0.	1.01	14.45	177	.02	.02	.00	12.
1.01	2.50	34	.01	.00	.01	0.	1.01	14.50	178	.02	.02	.00	11.
1.01	2.55	35	.01	.00	.01	0.	1.01	14.55	179	.02	.02	.00	11.
1.01	3.00	36	.01	.00	.01	0.	1.01	15.00	180	.02	.02	.00	11.
1.01	3.05	37	.01	.00	.01	0.	1.01	15.05	181	.02	.02	.00	10.
1.01	3.10	38	.01	.00	.01	0.	1.01	15.10	182	.02	.02	.00	9.
1.01	3.15	39	.01	.00	.01	0.	1.01	15.15	183	.02	.02	.00	9.
1.01	3.20	40	.01	.00	.01	0.	1.01	15.20	184	.02	.02	.00	9.
1.01	3.25	41	.01	.00	.01	0.	1.01	15.25	185	.02	.02	.00	9.
1.01	3.30	42	.01	.00	.01	0.	1.01	15.30	186	.02	.02	.00	9.
1.01	3.35	43	.01	.00	.01	0.	1.01	15.35	187	.02	.02	.00	9.
1.01	3.40	44	.01	.00	.01	0.	1.01	15.40	188	.02	.02	.00	9.
1.01	3.45	45	.01	.00	.01	0.	1.01	15.45	189	.02	.02	.00	9.
1.01	3.50	46	.01	.00	.01	0.	1.01	15.50	190	.02	.02	.00	9.
1.01	3.55	47	.01	.00	.01	0.	1.01	15.55	191	.02	.02	.00	9.
1.01	4.00	48	.01	.00	.01	0.	1.01	16.00	192	.02	.02	.00	9.
1.01	4.05	49	.01	.00	.01	0.	1.01	16.05	193	.02	.02	.00	9.
1.01	4.10	50	.01	.00	.01	0.	1.01	16.10	194	.02	.02	.00	9.
1.01	4.15	51	.01	.00	.01	0.	1.01	16.15	195	.02	.02	.00	9.
1.01	4.20	52	.01	.00	.01	0.	1.01	16.20	196	.02	.02	.00	9.
1.01	4.25	53	.01	.00	.01	0.	1.01	16.25	197	.02	.02	.00	9.
1.01	4.30	54	.01	.00	.01	0.	1.01	16.30	198	.02	.02	.00	9.
1.01	4.35	55	.01	.00	.01	0.	1.01	16.35	199	.02	.02	.00	9.
1.01	4.40	56	.01	.00	.01	0.	1.01	16.40	200	.02	.02	.00	9.
1.01	4.45	57	.01	.00	.01	0.	1.01	16.45	201	.02	.02	.00	9.
1.01	4.50	58	.01	.00	.01	0.	1.01	16.50	202	.02	.02	.00	9.
1.01	4.55	59	.01	.00	.01	0.	1.01	16.55	203	.02	.02	.00	9.
1.01	5.00	60	.01	.00	.01	0.	1.01	17.00	204	.02	.02	.00	9.
1.01	5.05	61	.01	.00	.01	0.	1.01	17.05	205	.02	.02	.00	9.
1.01	5.10	62	.01	.00	.01	0.	1.01	17.10	206	.02	.02	.00	9.
1.01	5.15	63	.01	.00	.01	0.	1.01	17.15	207	.02	.02	.00	9.
1.01	5.20	64	.01	.00	.01	0.	1.01	17.20	208	.02	.02	.00	9.
1.01	5.25	65	.01	.00	.01	0.	1.01	17.25	209	.02	.02	.00	9.
1.01	5.30	66	.01	.00	.01	0.	1.01	17.30	210	.02	.02	.00	9.
1.01	5.35	67	.01	.00	.01	0.	1.01	17.35	211	.02	.02	.00	9.
1.01	5.40	68	.01	.00	.01	0.	1.01	17.40	212	.02	.02	.00	9.
1.01	5.45	69	.01	.00	.01	0.	1.01	17.45	213	.02	.02	.00	9.
1.01	5.50	70	.01	.00	.01	0.	1.01	17.50	214	.02	.02	.00	9.
1.01	5.55	71	.01	.00	.01	1.	1.01	17.55	215	.02	.02	.00	9.
1.01	6.00	72	.01	.00	.01	1.	1.01	18.00	216	.02	.02	.00	9.
1.01	6.05	73	.02	.00	.01	1.	1.01	18.05	217	.01	.01	.00	5.
1.01	6.10	74	.02	.00	.01	2.	1.01	18.10	218	.01	.01	.00	4.
1.01	6.15	75	.02	.00	.01	2.	1.01	18.15	219	.01	.01	.00	3.
1.01	6.20	76	.02	.00	.01	2.	1.01	18.20	220	.01	.01	.00	3.
1.01	6.25	77	.02	.00	.01	2.	1.01	18.25	221	.01	.01	.00	3.
1.01	6.30	78	.02	.00	.01	2.	1.01	18.30	222	.01	.01	.00	3.
1.01	6.35	79	.02	.00	.01	2.	1.01	18.35	223	.01	.01	.00	3.
1.01	6.40	80	.02	.00	.01	2.	1.01	18.40	224	.01	.01	.00	3.
1.01	6.45	81	.02	.00	.01	3.	1.01	18.45	225	.01	.01	.00	3.
1.01	6.50	82	.02	.00	.01	3.	1.01	18.50	226	.01	.01	.00	3.
1.01	6.55	83	.02	.00	.01	3.	1.01	18.55	227	.01	.01	.00	3.
1.01	7.00	84	.02	.01	.01	3.	1.01	19.00	228	.01	.01	.00	3.

1.01	7.05	85	.02	.01	.01	3.	1.01	19.05	229	.01	.01	.00	3.
1.01	7.10	86	.02	.01	.01	3.	1.01	19.10	230	.01	.01	.00	3.
1.01	7.15	87	.02	.01	.01	3.	1.01	19.15	231	.01	.01	.00	3.
1.01	7.20	88	.02	.01	.01	3.	1.01	19.20	232	.01	.01	.00	3.
1.01	7.25	89	.02	.01	.01	3.	1.01	19.25	233	.01	.01	.00	3.
1.01	7.30	90	.02	.01	.01	4.	1.01	19.30	234	.01	.01	.00	3.
1.01	7.35	91	.02	.01	.01	4.	1.01	19.35	235	.01	.01	.00	3.
1.01	7.40	92	.02	.01	.01	4.	1.01	19.40	236	.01	.01	.00	3.
1.01	7.45	93	.02	.01	.01	4.	1.01	19.45	237	.01	.01	.00	3.
1.01	7.50	94	.02	.01	.01	4.	1.01	19.50	238	.01	.01	.00	3.
1.01	7.55	95	.02	.01	.01	4.	1.01	19.55	239	.01	.01	.00	3.
1.01	8.00	96	.02	.01	.01	4.	1.01	20.00	240	.01	.01	.00	3.
1.01	8.05	97	.02	.01	.01	4.	1.01	20.05	241	.01	.01	.00	3.
1.01	8.10	98	.02	.01	.01	4.	1.01	20.10	242	.01	.01	.00	3.
1.01	8.15	99	.02	.01	.01	4.	1.01	20.15	243	.01	.01	.00	3.
1.01	8.20	100	.02	.01	.01	4.	1.01	20.20	244	.01	.01	.00	3.
1.01	8.25	101	.02	.01	.01	4.	1.01	20.25	245	.01	.01	.00	3.
1.01	8.30	102	.02	.01	.01	5.	1.01	20.30	246	.01	.01	.00	3.
1.01	8.35	103	.02	.01	.01	5.	1.01	20.35	247	.01	.01	.00	3.
1.01	8.40	104	.02	.01	.01	5.	1.01	20.40	248	.01	.01	.00	3.
1.01	8.45	105	.02	.01	.01	5.	1.01	20.45	249	.01	.01	.00	3.
1.01	8.50	106	.02	.01	.01	5.	1.01	20.50	250	.01	.01	.00	3.
1.01	8.55	107	.02	.01	.01	5.	1.01	20.55	251	.01	.01	.00	3.
1.01	9.00	108	.02	.01	.01	5.	1.01	21.00	252	.01	.01	.00	3.
1.01	9.05	109	.02	.01	.01	7.	1.01	21.05	253	.01	.01	.00	3.
1.01	9.10	110	.02	.01	.01	7.	1.01	21.10	254	.01	.01	.00	3.
1.01	9.15	111	.02	.01	.01	8.	1.01	21.15	255	.01	.01	.00	3.
1.01	9.20	112	.02	.01	.01	8.	1.01	21.20	256	.01	.01	.00	3.
1.01	9.25	113	.02	.01	.01	8.	1.01	21.25	257	.01	.01	.00	3.
1.01	9.30	114	.02	.01	.01	8.	1.01	21.30	258	.01	.01	.00	3.
1.01	9.35	115	.02	.01	.01	8.	1.01	21.35	259	.01	.01	.00	3.
1.01	9.40	116	.02	.01	.01	8.	1.01	21.40	260	.01	.01	.00	3.
1.01	9.45	117	.02	.01	.01	8.	1.01	21.45	261	.01	.01	.00	3.
1.01	9.50	118	.02	.02	.01	9.	1.01	21.50	262	.01	.01	.00	3.
1.01	9.55	119	.02	.02	.01	9.	1.01	21.55	263	.01	.01	.00	3.
1.01	10.00	120	.02	.02	.01	9.	1.01	22.00	264	.01	.01	.00	3.
1.01	10.05	121	.02	.02	.01	9.	1.01	22.05	265	.01	.01	.00	3.
1.01	10.10	122	.02	.02	.01	9.	1.01	22.10	266	.01	.01	.00	3.
1.01	10.15	123	.02	.02	.01	9.	1.01	22.15	267	.01	.01	.00	3.
1.01	10.20	124	.02	.02	.01	9.	1.01	22.20	268	.01	.01	.00	3.
1.01	10.25	125	.02	.02	.01	9.	1.01	22.25	269	.01	.01	.00	3.
1.01	10.30	126	.02	.02	.01	9.	1.01	22.30	270	.01	.01	.00	3.
1.01	10.35	127	.03	.02	.01	12.	1.01	22.35	271	.01	.01	.00	3.
1.01	10.40	128	.03	.02	.01	13.	1.01	22.40	272	.01	.01	.00	3.
1.01	10.45	129	.03	.02	.01	13.	1.01	22.45	273	.01	.01	.00	3.
1.01	10.50	130	.03	.02	.01	13.	1.01	22.50	274	.01	.01	.00	3.
1.01	10.55	131	.03	.02	.01	13.	1.01	22.55	275	.01	.01	.00	3.
1.01	11.00	132	.03	.02	.01	14.	1.01	23.00	276	.01	.01	.00	3.
1.01	11.05	133	.07	.05	.02	24.	1.01	23.05	277	.01	.01	.00	3.
1.01	11.10	134	.07	.05	.02	28.	1.01	23.10	278	.01	.01	.00	3.
1.01	11.15	135	.07	.05	.02	29.	1.01	23.15	279	.01	.01	.00	3.
1.01	11.20	136	.07	.05	.02	30.	1.01	23.20	280	.01	.01	.00	3.
1.01	11.25	137	.07	.05	.02	31.	1.01	23.25	281	.01	.01	.00	3.
1.01	11.30	138	.07	.05	.01	31.	1.01	23.30	282	.01	.01	.00	3.
1.01	11.35	139	.13	.11	.03	52.	1.01	23.35	283	.01	.01	.00	3.
1.01	11.40	140	.13	.11	.03	60.	1.01	23.40	284	.01	.01	.00	3.

```
   1.01  11.45    141    .13    .11    .02     63.       1.01  23.45   285    .01    .01    .00     3.
   1.01  11.50    142    .26    .22    .04    104.       1.01  23.50   286    .01    .01    .00     3.
   1.01  11.55    143    .26    .22    .04    121.       1.01  23.55   287    .01    .01    .00     3.
   1.01  12.00    144    .56    .50    .06    272.       1.02    .00   288    .01    .01    .00     4.

                                                                       SUM   7.49   5.96   1.54    3582.
                                                                           ( 190.)( 151.)(  39.)(  95.77)

                        PEAK    6-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
              CFS       382.      38.      12.       12.        3409.
              CMS        11.       1.       0.        0.          97.
           INCHES                4.76     5.95      5.95        5.95
               MM              120.98   151.19    151.19      151.19
            AC-FT                 19.      23.       23.         23.
       THOUS CU M                 23.      29.       29.         29.


   **********     **********     **********     **********     **********

                         HYDROGRAPH ROUTING

        ROUTE THROUGH SPILLWAY

                 ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                     2       1       0       0       0       0       1       0       0
                                     ROUTING DATA
            QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP           LSTR
               .0    .000     .00       1       0       0       0              0

                 NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                     1       0       0    .000    .000    .000   -832.      -1

 STAGE     832.00    832.70    832.90    833.00    833.20    833.50    833.60    833.70    833.90    834.10
           834.30    835.00    836.00    838.00    839.50    841.00

 FLOW         .00      1.90      2.50      2.90      3.70      4.20      4.60      5.00      5.70      6.40
             6.90      8.00      9.90     11.10     12.70     13.10

SURFACE AREA=      0.       10.       20.

   CAPACITY=       0.       49.      102.

  ELEVATION=     818.      832.      845.

                 CREL   SPWID    COQW    EXPW    ELEVL    COQL   CAREA    EXPL
                832.0      .0      .0      .0       .0      .0      .0      .0

                                          DAM DATA
                                 TOPEL    COQD    EXPD   DAMWID
                                 874.6      .0      .0       0.

  CREST LENGTH      0.      96.     430.     490.     660.     770.    1210.    1790.    2030.    2150.
  AT OR BELOW
```

ELEVATION	834.6	835.3	835.9	836.1	836.4	836.6	837.4	837.5	838.5	840.?

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.05	1	.08	0.	0.	48.	872.0
1.01	.10	2	.17	0.	0.	48.	872.0
1.01	.15	3	.25	0.	0.	48.	872.0
1.01	.20	4	.33	0.	0.	48.	872.0
1.01	.25	5	.42	0.	0.	48.	872.0
1.01	.30	6	.50	0.	0.	48.	872.0
1.01	.35	7	.58	0.	0.	48.	872.0
1.01	.40	8	.67	0.	0.	48.	872.0
1.01	.45	9	.75	0.	0.	48.	872.0
1.01	.50	10	.83	0.	0.	48.	872.0
1.01	.55	11	.92	0.	0.	48.	872.0
1.01	1.00	12	1.00	0.	0.	48.	872.0
1.01	1.05	13	1.08	0.	0.	48.	872.0
1.01	1.10	14	1.17	0.	0.	48.	872.0
1.01	1.15	15	1.25	0.	0.	48.	872.0
1.01	1.20	16	1.33	0.	0.	48.	872.0
1.01	1.25	17	1.42	0.	0.	48.	872.0
1.01	1.30	18	1.50	0.	0.	48.	872.0
1.01	1.35	19	1.58	0.	0.	48.	872.0
1.01	1.40	20	1.67	0.	0.	48.	872.0
1.01	1.45	21	1.75	0.	0.	48.	872.0
1.01	1.50	22	1.83	0.	0.	48.	872.0
1.01	1.55	23	1.92	0.	0.	48.	872.0
1.01	2.00	24	2.00	0.	0.	48.	872.0
1.01	2.05	25	2.08	0.	0.	48.	872.0
1.01	2.10	26	2.17	0.	0.	48.	872.0
1.01	2.15	27	2.25	0.	0.	48.	872.0
1.01	2.20	28	2.33	0.	0.	48.	872.0
1.01	2.25	29	2.42	0.	0.	48.	872.0
1.01	2.30	30	2.50	0.	0.	48.	872.0
1.01	2.35	31	2.58	0.	0.	48.	872.0
1.01	2.40	32	2.67	0.	0.	48.	872.0
1.01	2.45	33	2.75	0.	0.	48.	872.0
1.01	2.50	34	2.83	0.	0.	48.	872.0
1.01	2.55	35	2.92	0.	0.	48.	872.0
1.01	3.00	36	3.00	0.	0.	48.	872.0
1.01	3.05	37	3.08	0.	0.	48.	872.0
1.01	3.10	38	3.17	0.	0.	48.	872.0
1.01	3.15	39	3.25	0.	0.	48.	872.0
1.01	3.20	40	3.33	0.	0.	48.	872.0
1.01	3.25	41	3.42	0.	0.	48.	872.0
1.01	3.30	42	3.50	0.	0.	48.	872.0
1.01	3.35	43	3.58	0.	0.	48.	872.0
1.01	3.40	44	3.67	0.	0.	48.	872.0
1.01	3.45	45	3.75	0.	0.	48.	872.0
1.01	3.50	46	3.83	0.	0.	48.	872.0
1.01	3.55	47	3.92	0.	0.	48.	872.0
1.01	4.00	48	4.00	0.	0.	48.	872.0
1.01	4.05	49	4.08	0.	0.	48.	872.0
1.01	4.10	50	4.17	0.	0.	48.	872.0
1.01	4.15	51	4.25	0.	0.	48.	872.0

B L A C K   &   V E A T C H   PROJECT 5472:   DATE 02 JAN 81   PAGE

FLOOD HYDROGRAPH PACKAGE - HEC-1   PROGRAM HEC1(2-1V   TIME 10:01:

1.01	23.00	276	23.00	3.	5.	67.	[illegible]
1.01	23.05	277	23.08	3.	5.	67.	[illegible]
1.01	23.10	278	23.17	3.	5.	67.	[illegible]
1.01	23.15	279	23.25	3.	5.	67.	[illegible]
1.01	23.20	280	23.33	3.	5.	67.	[illegible]
1.01	23.25	281	23.42	3.	5.	67.	[illegible]
1.01	23.30	282	23.50	3.	5.	67.	[illegible]
1.01	23.35	283	23.58	3.	5.	67.	[illegible]
1.01	23.40	284	23.67	3.	5.	67.	[illegible]
1.01	23.45	285	23.75	3.	5.	67.	[illegible]
1.01	23.50	286	23.83	3.	5.	67.	[illegible]
1.01	23.55	287	23.92	3.	5.	67.	[illegible]
1.02	.00	288	24.00	3.	5.	67.	[illegible]

PEAK OUTFLOW IS   5. AT TIME 16.08 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5.	5.	4.	2.	684.
CMS	0.	0.	0.	0.	19.
INCHES		.60	1.19	1.19	1.19
MM		15.31	30.35	30.35	30.35
AC-FT		2.	5.	5.	5.
THOUS CU M		3.	6.	6.	6.

**********   **********   **********   **********   **********

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	382.	38.	12.	12.	.07
	(	10.81)(	1.07)(	.34)(	.34)(	.19)
ROUTED TO	2	5.	5.	2.	2.	.07
	(	.14)(	.14)(	.07)(	.07)(	.19)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	832.00	832.00	834.60
STORAGE	48.	48.	80.
OUTFLOW	0.	0.	7.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	833.67	.00	67.	5.	.00	16.0[illegible]	.00

[illegible]

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